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SCIENCE AND YOU

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SCIENCE AND YOU

BOOK II

MAN USES HIS DISCOVERIES

BY

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INSTITUTE OF EDUCATION FOR WOMEN
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LONDON
EDWARD ARNOLD (PUBLISHERS) LTD

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First published 1955

The other books in this series are:

BOOK I: From Simple Experiments

BOOK III: The Growth of Science

BOOK IV: Science Today

Acc No— 14947

Printed and bound in Great Britain
by Jarrold and Sons Ltd, Norwich

FOREWORD

THIS is the second book in a series of four intended principally for Secondary Modern Schools. Book I stressed mainly the simple beginnings and experiments in relation to present-day life. This book, entitled *Man Uses His Discoveries* continues this theme. It shows for instance how man has used his knowledge, gained by experiment and observation to improve his way of life. How he has used his knowledge of the air to fly and to glide, and of water to travel both upon and under the sea. It shows how he uses to best advantage materials for his clothing and for building his home. It shows, too, how many of the tricks of the circus ring have been brought about.

Our eyes can be deceived. A section of this book deals very simply with the eye, and again the fact that our eyes do not always tell the truth is sometimes turned to advantage. From watching Nature, ways have been found to hide ourselves from view, and even to appear to be what we are not.

From knowledge gained from experiment and observation in all branches of science, agriculture has become a science in itself, a blending of physics, chemistry and biology. Similarly our standard of living has improved both as regards food and health.

Stress is laid on the fact that science deals with real things, and that it must be considered as a whole. The aim is to catch and hold the interest of the children so that through this stimulation they will be encouraged to look for themselves and find out for themselves more and more about the ways in which science affects their everyday life.

As in Book I, I have given some simple experiments that make use of very little apparatus other than that which can be found in most homes, but I would like to add that wherever possible, the experimental side of the subject should be further developed.

I wish to thank Diana Buckland whose work appears on page 23; Mr. Alan Hall, Mr. R. Hartridge of Burnt Ash Library, Bromley; The London Transport Executive; and finally my wife for her invaluable assistance.

G. E. J. R.

NOTES FOR TEACHERS

The material in this book is not divided into the conventional chapters; but to assist teaching it will be found that the subject matter falls into the following divisions:

pages
5–21 *Air: Balloons, Flying, Pressure*
22–23 *A record book*
24–37 *Water: Divers, Ships, Submarines*
38–63 *Heat: Convection, Conduction, Radiation*
64–81 *Light: Optical illusions, camouflage*
82–97 *Electricity*
98–111 *Gravity and Balancing*
112–127 *Plants and the soil*
128–151 *Health and food*
152–156 *Revision and Conclusion*

The following acknowledgements are gladly made: to Sir Edward Salisbury, F.R.S., for the photographs on page 113; to the U.S. Information Service for the photograph on the top half of page 115; to the Royal Dutch Airline for the photograph on the bottom half of page 115; to the *Farmer and Stockbreeder* for the photograph on page 116; to the C.O.I. for the photograph on page 117, which is Crown Copyright; to the Bentham Trustees for the photographs on page 125; to the Wellcome Historical Medical Museum for the photograph on page 130; to the C.O.I. for the photograph on page 131, which is Crown Copyright; to the Macmillan Company of New York for the map on page 129; to the Ministry of Health for the photograph on page 128, which is Crown Copyright; and to Mr. John Barlee and William Collins, Sons & Co. Ltd., for permission to base the drawings of birds in flight on pages 14 and 15 upon the bird photographs in his *Birds on the Wing*.

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MAN USES HIS DISCOVERIES

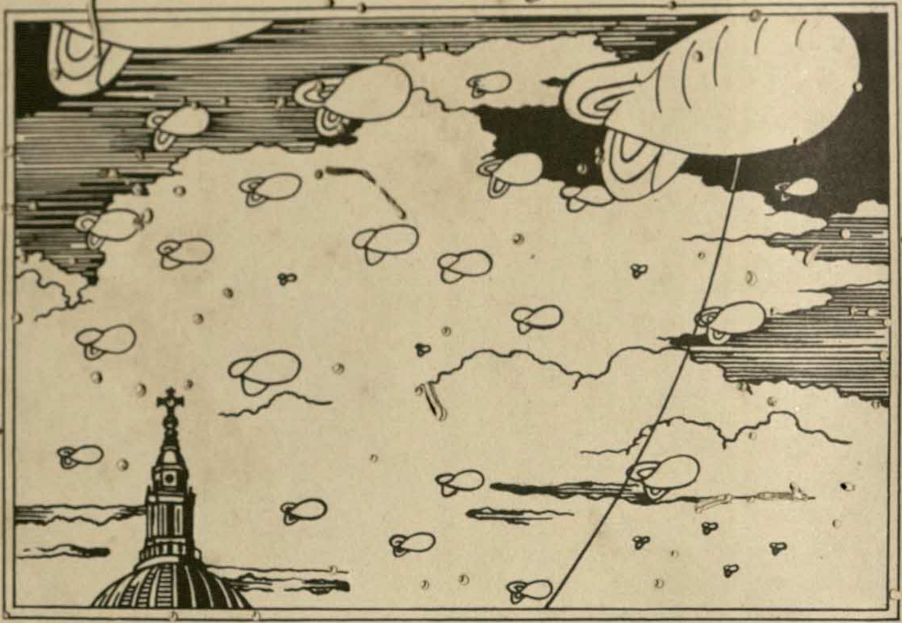
WHEN we began this course in Book I we stressed the simple beginnings of science and how they have affected us in our everyday life. You had quite a lot of research to do on your own, looking up references and finding out things for yourself. I hope you enjoyed doing this, because in this second book, which is called *Man Uses His Discoveries* there are again a lot of things for you to do. We shall continue to follow the progress of science here. You will see how many of the everyday things about us developed from simple beginnings, and how from observation and experiment we have been able to adapt these discoveries to our own uses. Man has learnt to imitate the birds of the air, for today he can fly with the aid of machines. Man has learnt from Nature many things, and again has made this knowledge serve him. Today he can travel both under the sea, and on it.

Electricity has given us many benefits, and is responsible for many of the things we accept today without even thinking about them, and the beginnings of all of them were those simple early experiments.

Because we know much more today about the living things at work about us, we live more healthily, and our standards of food and cleanliness are better today probably than they have ever been. We shall find out how this has come about.

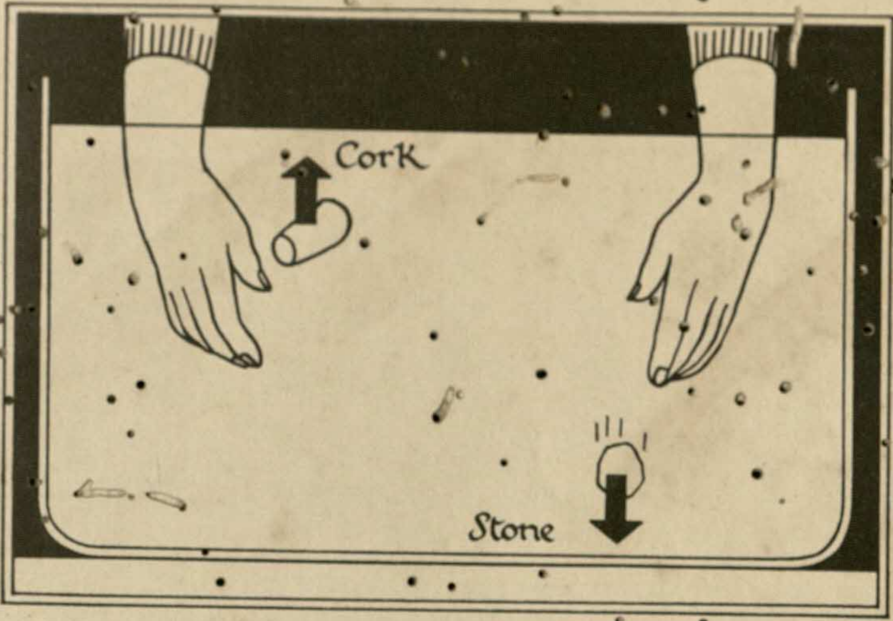
We shall see why thatched or tiled houses are pleasanter to live in than a house made entirely of metal. By the time you have completed this book you will, I hope, have had answered many of the questions you may be asking now.

BARRAGE BALLOONS—



BLOW up a toy balloon, hold it in the air and let it go. Does it float or fall? Do the same with another balloon filled with coal gas. What happens this time? Do you know why?

You have already seen that moving air can be very powerful and that it will move very heavy things. Moving air is made use of by birds and aeroplanes when they are flying. They can only stay up in the air whilst they are moving, and as soon as movement stops they fall. Barrage balloons on the other hand stay up in the air without moving. If, by some means, it were possible to lift a balloon and an aeroplane several hundred feet into the air and then to let them go, the balloon would float in the air and the aeroplane would crash to the ground. It is rather like holding a piece of cork and a piece of stone on the surface of water and trying to float them. Just as the balloon will float in the air, so the cork floats on the surface of the water, but the aeroplane and the stone sink, the one to the ground and the other to the bottom of the water. In both cases one substance is lighter than the other. The stone sinks in water because it is heavier than an equal volume of

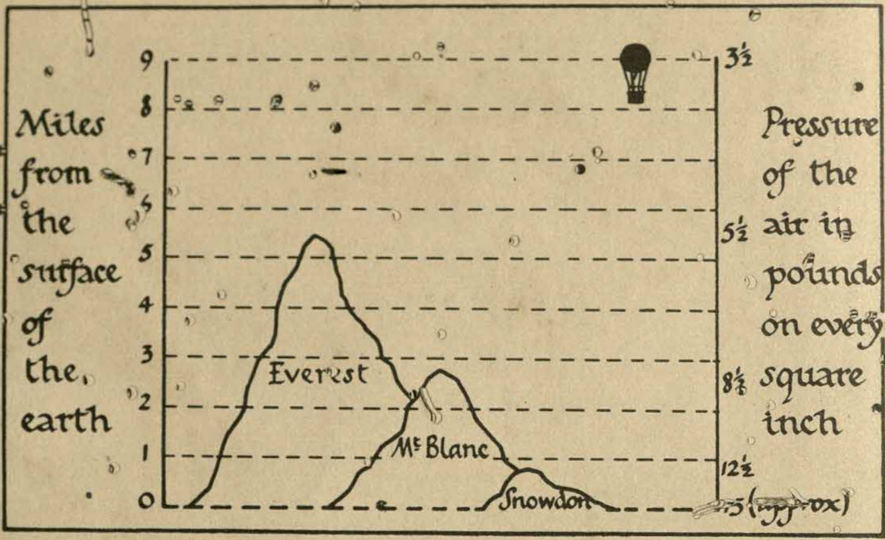


water, and the aeroplane sinks because it is heavier than an equal volume of air.

How do you think the weights of the cork and an equal volume of water compare?

Why does a barrage balloon float in air? As long as the weight of the bag and the gas inside it is less than the weight of the same volume of air it will stay up. How does the weight of the balloon fabric compare with that of the air? Do you think a barrage balloon filled with ordinary air would float? Like your toy balloon filled with air it will not rise, but if it is filled with a gas which is lighter than air it will. Coal gas is lighter than air. So is hydrogen, and in the early experiments this was used to fill balloons and airships. But because hydrogen burns easily, helium, another light gas, is used instead today.

The air gradually becomes thinner the higher you go, as mountaineers have found, and there comes a time when the air is so thin that the balloon weighs as much as the air it displaces, and then it will rise no further.



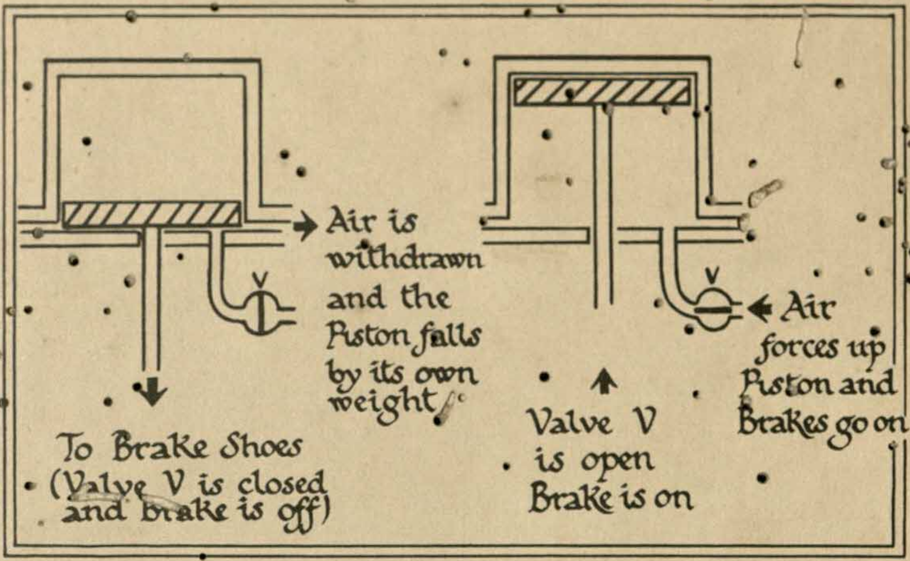
ONE of the facts we have discovered about the air is that it can be compressed or squeezed into a smaller space. We do this every time we pump up a bicycle tyre. Gases like air and oxygen are often stored and carried about in heavy steel cylinders. In these the gases are very highly compressed. A cylinder of oxygen open to the air would contain about an ounce of oxygen, but when it is full of compressed oxygen, the gas will weigh about 8 pounds.

Air on the earth's surface has all the air above it pressing down on it, so that it will be compressed by its own weight. As we go higher there is less air above and, therefore, the air is not compressed so much.

Which takes up more room, a pound of air on the surface of the earth, or a pound of air on the top of Mount Everest? Right at the top of Mount Everest, that is, about 5½ miles high, the same volume of air weighs roughly a third of what it does on the earth's surface.

A balloon that is free to rise will do so until its weight is the same as the weight of an equal volume of air. So you see, since the air gets thinner and lighter as we go up, a balloon will not go on rising for ever.

—A BALLOON RISE?


Air is withdrawn and the Piston falls by its own weight
V
To Brake Shoes
(Valve V is closed and brake is off)
V
Air
Air forces up Piston and Brakes go on
Valve V is open Brake is on

Balloons are used to help forecast the weather, and as they have to rise to very great heights they are only partly filled with gas. Do you know why? We will talk about this in our next lesson. Meanwhile see if you can find the answer.

The pressure of the air on the surface of the earth is equal to that of a weight of 15 pounds acting on every square inch, and this pressure is acting in all directions. It is because the pressure acts in all directions that cardboard boxes and thin glass vessels do not collapse under the pressure of the air. This great pressure is sometimes made to do useful work as in the vacuum brakes fitted to certain trains. The picture shows you how they work. Inside a cylinder is a piston that can move up and down. Attached to the piston is a series of rods and levers that are connected to the brakes. These brake cylinders are connected to one another by means of flexible hoses from carriage to carriage. Air is taken out of the brake cylinder on both sides of the piston by the motor or engine, so that there is no pressure on either side of the piston, and it rests as shown. When a coupling breaks, air rushes in through the hose, forces the piston to the top of the cylinder, so applying the brakes.

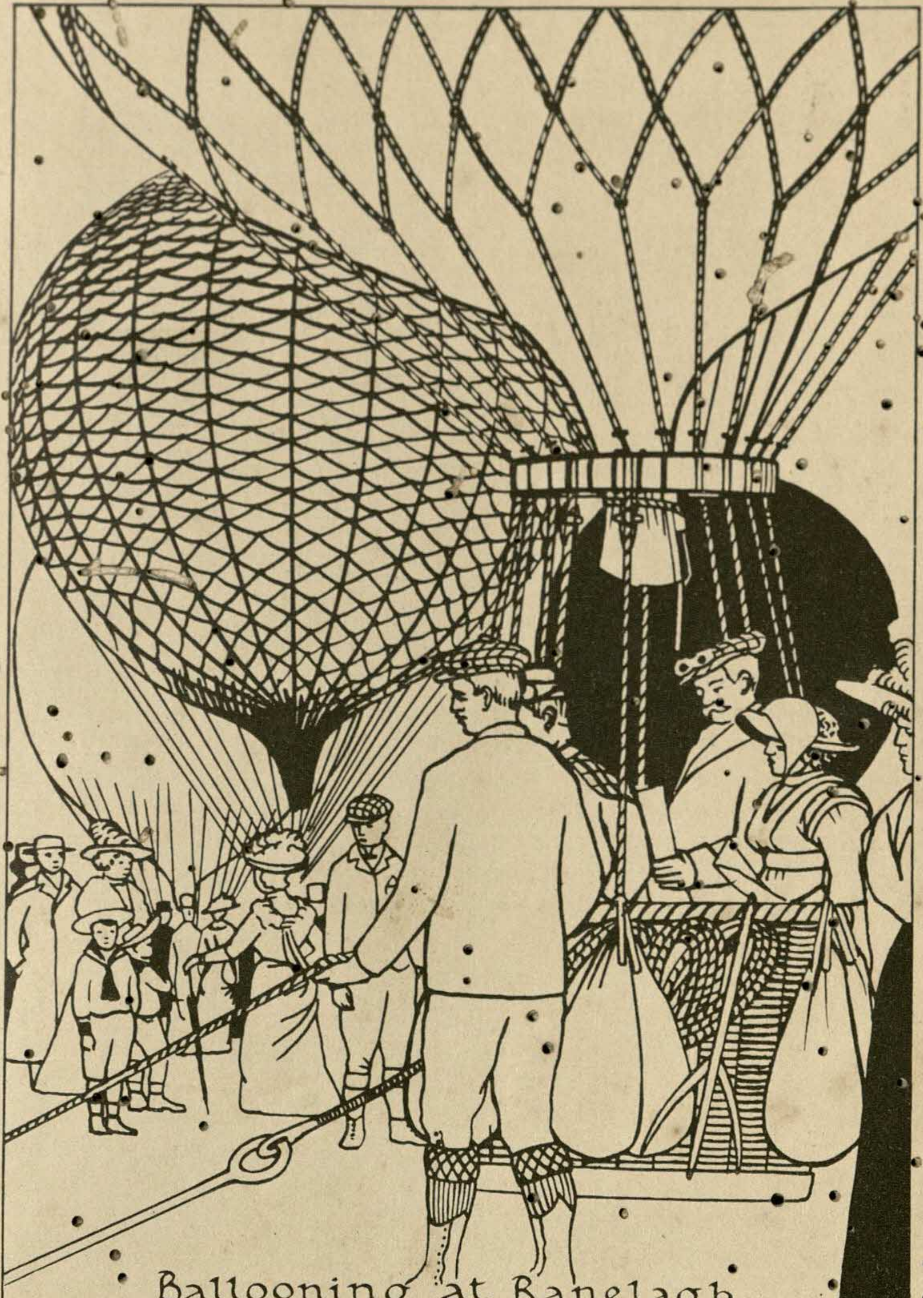
BALLOONS THAT GO TO GREAT HEIGHTS

DO you know what a meteorological balloon is? It is sometimes called a "Met." balloon for short. These balloons carry measuring instruments which give information needed for forecasting the weather. The balloons have to go up to very great heights, and as you know, the higher the balloons go the smaller will be the air pressure outside. At a height of 20,000 feet, the pressure of the air has fallen to about 7 or 8 pounds on every square inch. How many miles up is this?

If the balloon is filled with gas on the ground so that the pressure inside the balloon is about 15 pounds per square inch, as the balloon rises, the pressure outside the balloon will become less than the pressure inside the balloon. Suppose that the balloon were suddenly and safely taken to a height of 20,000 feet. The pressure outside would be about 7 pounds on every square inch, while the pressure inside would be 15 pounds per square inch. This means that there is an unbalanced pressure of 8 pounds on every square inch of the fabric. No material could stand that and the balloon would burst. What would happen if the balloon was only partly inflated? What would happen to the size of the balloon as it ascended? If the balloon expanded what happens to the pressure inside?

Although these meteorological balloons do not carry any men but only instruments, much larger balloons were once used to carry people. The control of the old balloons was quite a "hit and miss" affair. When they had risen to very great heights, and therefore to very low pressures, to prevent the balloon from bursting, some gas was let out of the bag by means of a release valve. The difficulty was that if too much gas was let out the balloon began to fall. If that happened, ballast, often in the form of sand, had to be thrown overboard. When the balloonists did decide to land, a combination of releasing gas and dumping ballast might be found that would bring the balloon down slowly, providing that the wind did not play any tricks. In case the balloon and its occupants were blown along, on or near the ground, part of the equipment carried were grappling irons to attempt to catch hold of hedges and trees. More than one balloon trip ended with the slitting of the balloon with a knife and so releasing the gas.

What is meant when an aeroplane is "pressurised"? How do pilots of high-flying fighter planes overcome the shortage of oxygen at high altitudes?



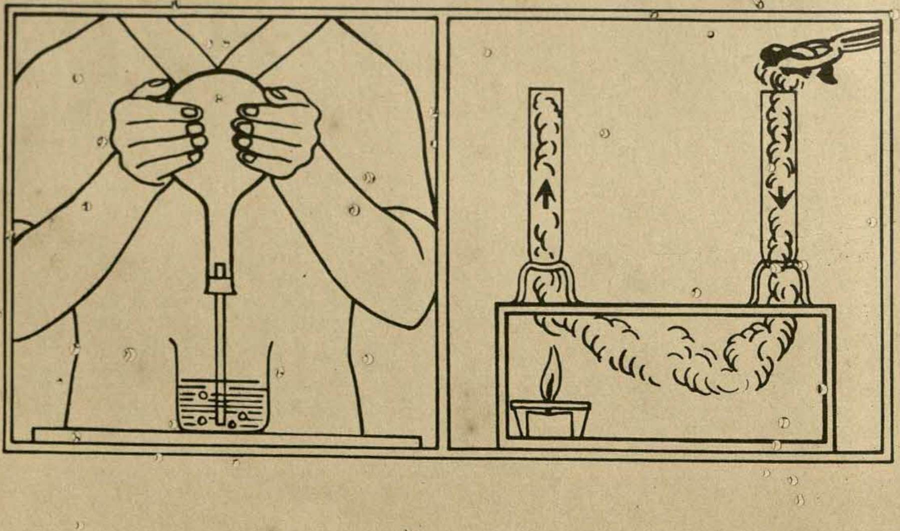
Ballooning at Ranelagh.

LIFTING A BALLOON—

WHEN solids such as pieces of metal are heated they expand, and you have already seen that allowances sometimes have to be made to avoid damage or accidents due to expansion. Both liquids and gases also expand when they are heated.

Fit a glass flask or a bottle with a cork. Into the cork fit a length of glass tubing, as shown in the picture. The open end of the tubing must now be put below the level of some water in a basin. Now warm the flask with your hands. Do you see air bubbles coming from the end of the tube? Why is this?

When a bicycle tyre is pumped up in the cool of the morning and then is left out in hot sunshine later on in the day, the tyre becomes hot, the air inside will be heated and expand. If the tyre is hard the air cannot take up more room, so the air pressure inside goes up and the tyre becomes even harder. Air and other gases when they are heated expand, and if they can take up extra room they will. As a result hot air is lighter, volume for volume, than cold air, and so the hot air rises up above the cold air. One way of showing that hot air rises is to use a piece of apparatus like that shown in the diagram. A wooden box which is fitted with a glass front has two glass chimneys. Under one of the chimneys a lighted candle is placed. Over the top of the other chimney a piece of smouldering paper or rag is held. Smoke from the rag is drawn down the chimney and is seen passing through the box and up the other chimney over the candle.

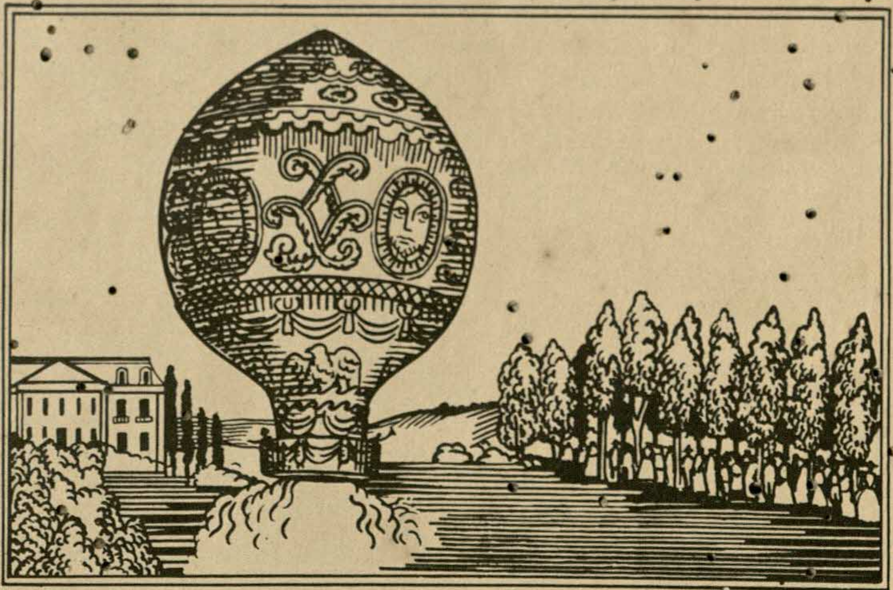


—WITH HOT AIR

Fire balloons first carried men in the year 1783, and as the name suggests, these balloons made use of hot air from a fire. Of course such balloons were dangerous, but they made many successful flights. A fire was sometimes suspended beneath an opening in the fabric of the balloon, filling it with hot air, and because hot air weighs less than an equal volume of cold air the balloon rose up, just as a balloon filled with hydrogen or helium will rise.

Can you answer the following questions?

1. A fireman entering a burning room crawls along the floor. Why?
2. A fire will not burn properly in a room with all the windows and doors sealed because (*a*) the hot air cannot get out, or (*b*) fresh air cannot get in.
3. Sparks fly upwards from a fire because (*a*) they are lighter than air, or because (*b*) they are taken up by the hot air which is rising from the fire.
4. How were fires used to supply fresh air to miners? (Your library may help you with this one.)

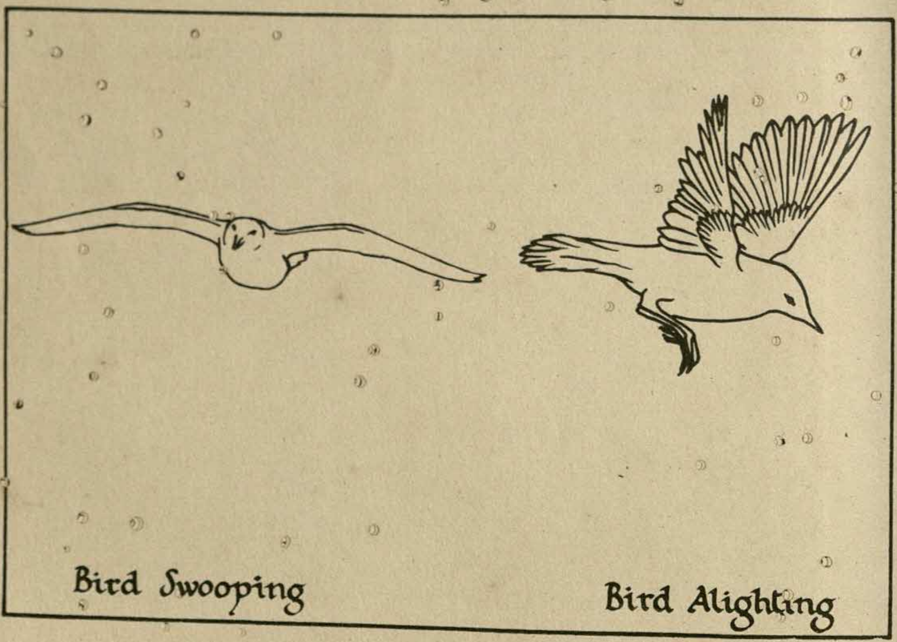


BIRDS CAN SWOOP—

HAVE you ever watched a bird hovering in mid-air? It seems to stay still in the sky, yet all the time its wings are moving very rapidly. Suddenly it swoops down to earth. Next time you take a walk, watch out especially for the birds. Notice how they land on the ground, or even how ducks land on water. The swooping bird travels very much faster than the bird landing.

But in both of the above cases the bird is moving and at the same time compressing the air in front of it. In one case more air is being compressed than in the other. Which one is this? How quickly the air slows down the bird will depend upon the area of the bird that is moving against the air. The swooping bird will compress less air than the bird landing normally because there is less area against the air. Look at the two diagrams and compare them.

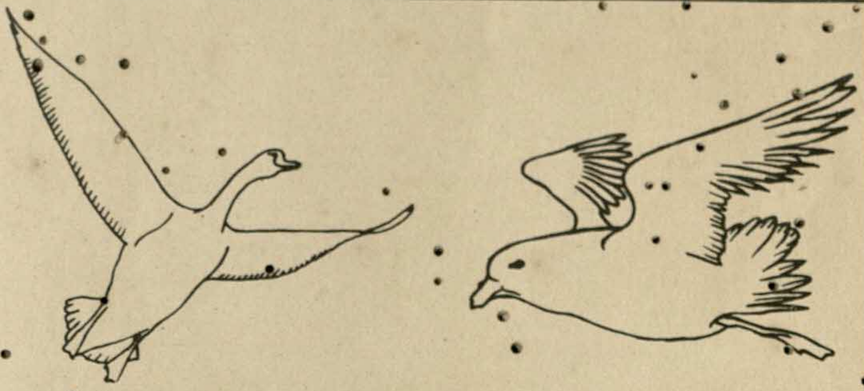
If the air in front of the bird is compressed, what happens to the air behind the bird? What is the opposite of compressed? Have you heard of the word 'rarefied'. Look it up in your dictionary. The air behind a moving bird can be said to be rarefied. The air in front of



the bird is compressed, and it presses against the bird more strongly than does the air behind the bird. Because of this increased air pressure in front of the bird, together with the decreased air pressure behind, the bird is slowed down.

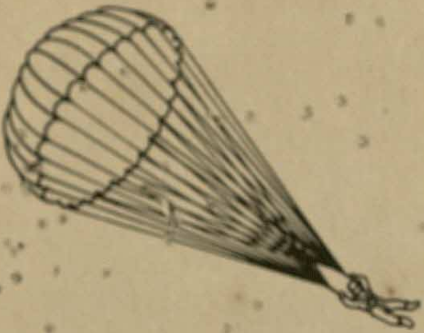
As a bird flies the wings sweep downwards and backwards. This compresses the air below and so supports the bird and at the same time the bird is forced forwards. Why does not the opposite happen when the wings beat upwards? Look carefully at the diagrams. On the down beat the wing feathers are seen to overlap so that the air cannot pass through them, but on the upward sweep the air is allowed to pass through the feathers, so that the bird is not forced down.

What happens when winged insects fly? They have no feathers to allow the air to pass through. How does Nature arrange that they can stay in the air? Make some pictures showing the difference between bird's and insect's wings, and mark the air pressure with arrows of different size to show compression and rarefaction.



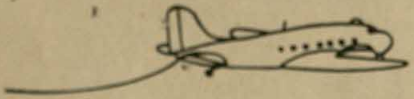
Downward beat Feathers closed   Upward beat Feathers open

PARACHUTES.–

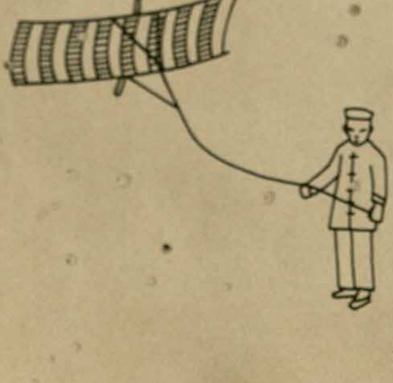


HAVE you ever tied a stone with string to the four corners of a square piece of rag and then thrown it into the air? This makes a parachute and the stone falls to the ground much more slowly than it would have done without the parachute. Try varying the size of the parachute and see what happens. When the area of the parachute is made larger does the stone fall more quickly or more slowly?

As the stone falls through the air the parachute above it compresses the air and it is this compressed air that makes the fall slower. In the early parachutes the air that was compressed beneath caused them to tilt from side to side and this made the descent more unpleasant than it need have been. This tilting is avoided by leaving a small hole at the centre of the parachute.



Have you ever seen a glider become airborne? One method used is to tow the glider by cable on a winch, and sometimes it is towed by an aeroplane. The glider is hauled along until a sufficiently high speed is reached and the glider leaves the ground. Do you know of any other method used to get a glider into the air? A glider weighs much less than an aeroplane and also it has a large surface area. Once the glider is in the air it is reasonably easy to keep it

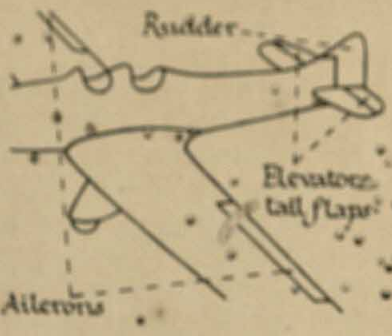


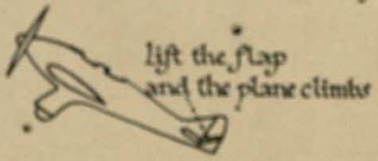
there. A certain speed must be kept up and having no engine it gets this speed by gliding downwards and thus its weight helps it to fly.

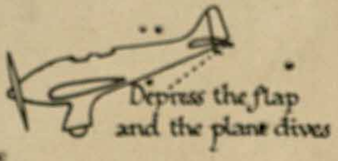
Just as there are currents in the sea, so there are currents in the air, and it is these currents that are used to keep a glider up. Without upward currents of air the glider would not be able to stay up. The upward movement of these air currents is greater than the downward movement of the glider so that the glider remains airborne and when conditions are good it can rise to great heights, and travel great distances.

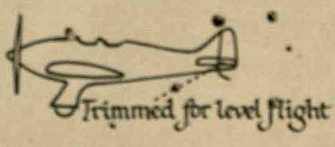
As with the birds, the glider, and the kite as well for that matter, are kept aloft by the compressed air underneath the lower surface of the wings. At the same time the air above is the opposite of compressed. Do you remember the word?

In the diagram of the aeroplane the ailerons (wing flaps), the elevators (tail flaps) and the rudder are marked. Make a simple cardboard model of the wings and tail unit, and try to explain how the aeroplane is controlled by these moving parts. Remember, the larger the area exposed, the larger the area of the compressed air, and therefore the greater the slowing down of that surface.





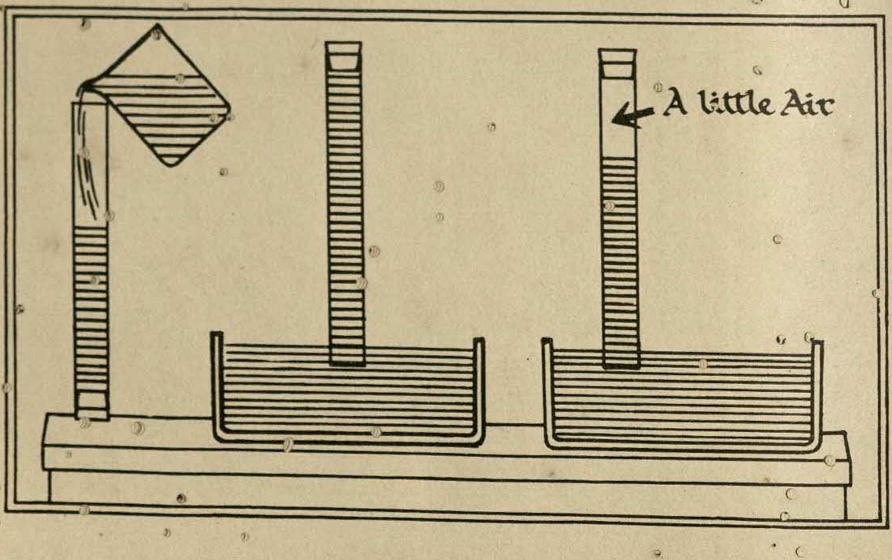




AIR PRESSURE—

THE air presses in all directions at once. The pressure is only noticed when air is allowed to press on one side of an object only. Of course, this only refers to "still air", and not "moving air". Do you remember how you filled a glass with water and covered it with a piece of card? What happened when the glass of water with the card was turned upside down? At the time we said that the air below the card was pressing up more strongly than the water pressed down on the card, thus the card remained under the water, holding it in the glass. In this instance the air was pressing only on one surface of the card, the under-surface.

Now try another simple experiment. Cork one end of a long glass tube and fill it with water. Close the other end with a rubber pad, turn the tube upside down, and put the end where your pad is under some water. Take away the pad. What happens to the water in the tube? Has the level changed? Loosen the cork slightly and allow some air to enter the tube. The level of the water in the tube falls a little. Because only a small amount of air has entered the tube it cannot press down hard enough to push all the water out of the tube, so the level of the water falls only a little way. What happens when the cork is taken right out of the tube? Can you explain this?

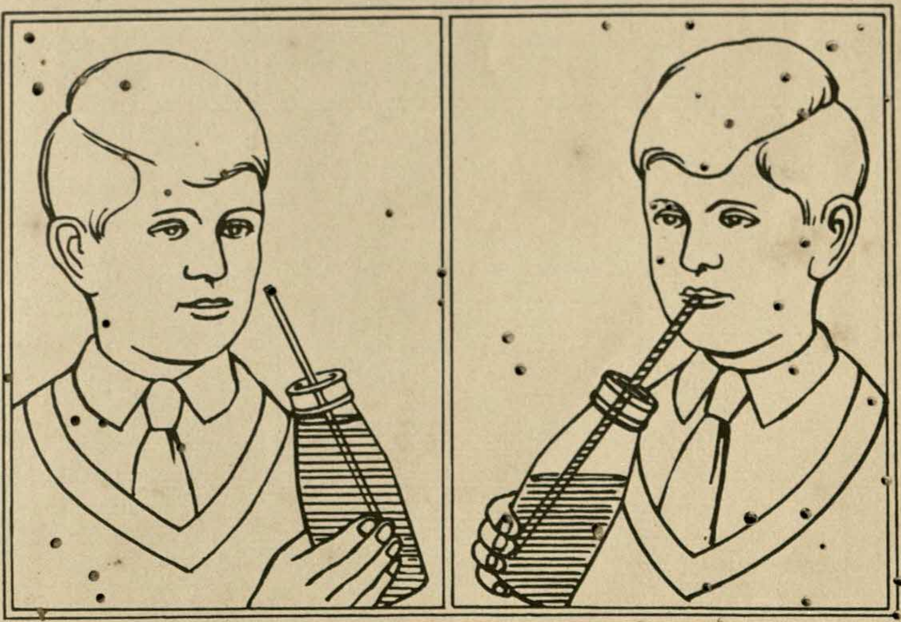


—AND DRINKING-STRAWS

When you use a drinking-straw you reverse the stages in the experiment you have just done. When the straw is put into a glass or a bottle of milk the liquid rises in the straw up to the level of the liquid in the glass or bottle. The pressure on the liquid in the straw is the same as the pressure on the liquid outside the straw. Nothing happens until you "suck" at the other end. As soon as you suck at the other end of the straw some of the air is taken out of it. This means that the air left in the tube cannot press down as hard as the air outside. So some of the liquid is forced up into the tube. Of course, the more air that you draw out of the straw the higher the liquid rises.

The pressure of the air is so strong that it will hold up a very long column of water, nearly 34 feet. If the column of water is longer than this, some of the water will run out of the tube until the weight of the water is balanced by the pressure of the air.

Mercury is 13½ times as heavy as water. What length column of mercury can air hold up?

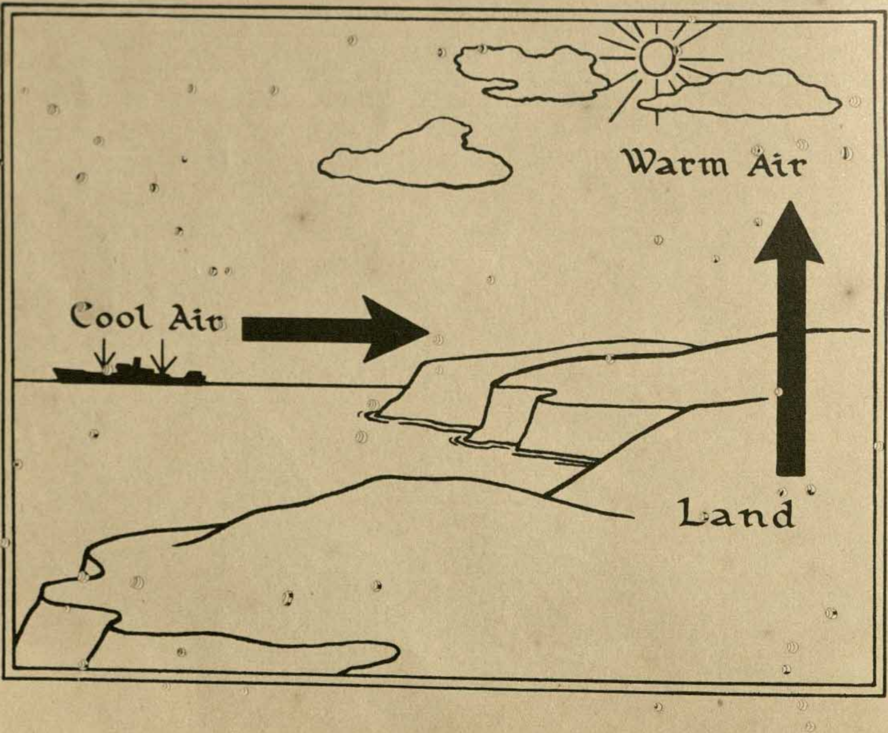


SEA BREEZES—

WHEN you were at the seaside did you notice that the breeze very often came from the sea to the land in the early part of the day, but in the evening the wind blew in the other direction?

In the morning when the sun rises it begins to warm up the land and the sea. The land warms up faster than the sea, because less heat is needed to warm the earth than the water. Therefore, the air above the land is warmed more than the air above the sea which stays quite cool. The warmed air over the land rises, and cool air off the sea flows in to take its place. So in the early morning the breeze is from the sea to the land. The arrows in the picture show the direction of this air movement.

Later in the day, both the land and the sea become warmed by the sun and there is generally less, or no air movement. But when the sun begins to set both the land and the sea begin to cool down; the land cools more quickly than the sea. Can you fill in the missing words in the next paragraph?

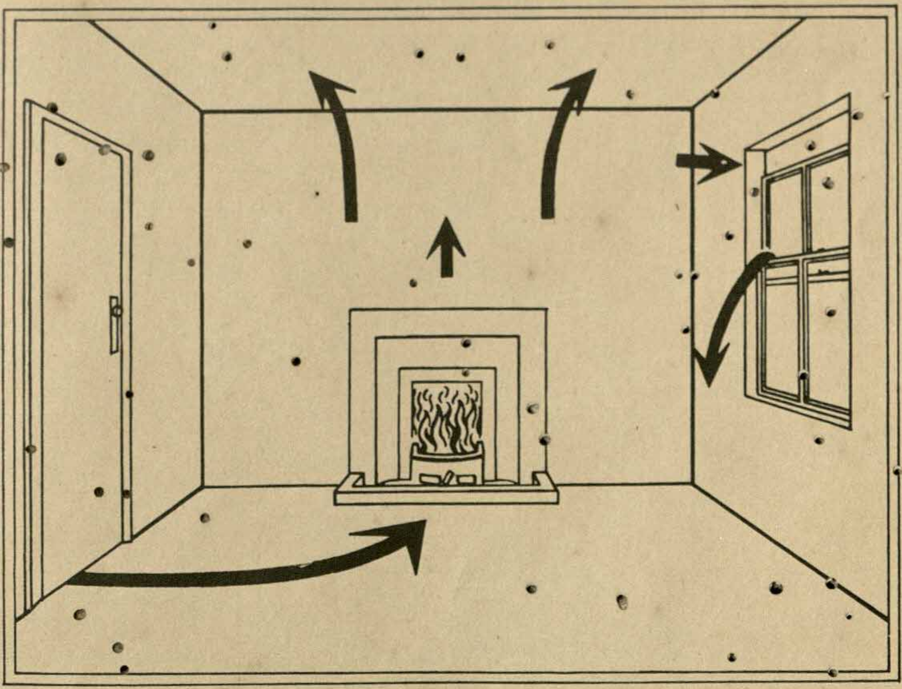


—AND LAND BREEZES

"As the land and the sea cool, the air above them —— as well. Since the land cools more —— than the sea, the air above the land becomes —— than the air above the sea. The warmer air above the —— now rises, and the —— air above the land flows in to take its place. This means that the direction of the breeze is from the —— to the ——."

This movement of air on a smaller scale occurs in a room, or a classroom, or theatre, or in fact anywhere where one part is warmer than another, even if the warmth of the human body is the only way in which the air is heated.

Make a large copy of the drawing of the room that is shown and put in the arrows and show which ones represent hot air and which ones represent cold air, by drawing red arrows for the hot air and blue ones for the cold air. If you have no coloured pencils just write the words 'hot' and 'cold' by the arrows.



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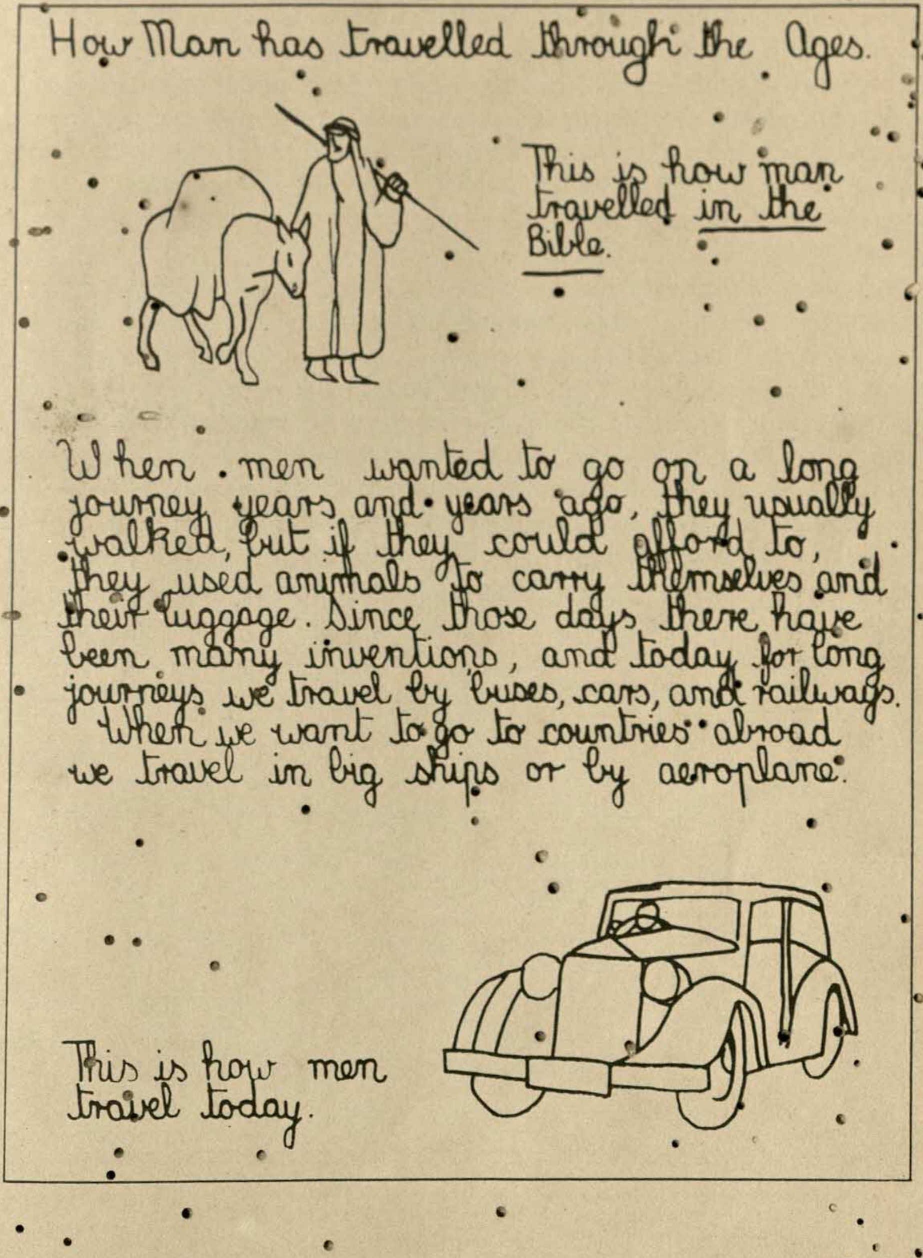
NOW YOU WILL KEEP A RECORD OF YOUR WORK

DURING the year of the course covered in this book I hope that you will all keep a record book. In it you will be able to write out the experiments that you do. You can make drawings and sketches, and in fact include anything that has interested you so far, and anything that particularly interests you as you work through this book. But, of course, only matters concerning science must be put into your record book. Keep it neatly, and avoid writing only notes that are just a shortened version of this book. All the work must be your very own, although you may get help from your teacher with some parts of it.

By now, no doubt, you will have found more than just one or two topics that interest you especially in this course of science. Your interest may have led you to your Public Library in order to find out more about certain topics. Maybe it was the work of a famous scientist, and during your search you discovered the conditions under which that scientist worked, and what life was like during his lifetime. You may have become interested in the means of lighting through the ages. Whatever topic of science you are particularly interested in can be recorded in your record book. But do not keep to only one or two topics: make your book varied and interesting to read, and you will be proud to have it.

Here is a page from a notebook which was done by a girl of eleven years old. The pages in your record book could be done something like this.



How Man has travelled through the Ages.

This is how man travelled in the Bible.

When men wanted to go on a long journey years and years ago, they usually walked, but if they could afford to, they used animals to carry themselves and their luggage. Since those days there have been many inventions, and today for long journeys we travel by buses, cars, and railways. When we want to go to countries abroad we travel in big ships or by aeroplane.

This is how men travel today.

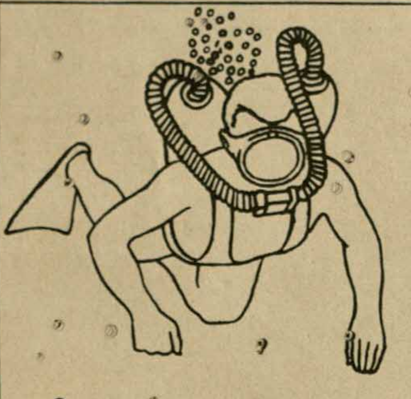
WHY THE SEAS—

THE oceans of the world cover nearly three-quarters of the globe, and even if we take away the shallow parts around the coasts we are still left with nearly one half of the earth's surface that is covered by water. Some of these waters are miles deep, and very little is known of their secret depths.

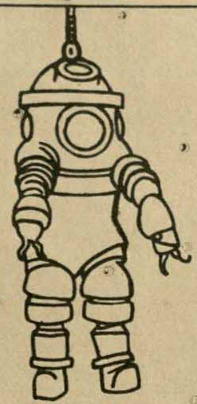
With the aid of different instruments, the scientist has some slight idea of the conditions to be found in such deep waters. He knows, for example, the temperature of the water, and how salt it is, but so far no one has been able to say what it is really like on the sea bed at these great depths.

Exploration of the sea has taken place, but even with all the help that science can give man can only descend a little way. Wearing just a diving helmet, so that his supply of air is assured, a man can descend to a depth of some 60 feet and stay there safely. Under these conditions he has a certain amount of freedom in his movements, but as soon as he wants to go deeper he can do so only at a loss of this freedom. Wearing a complete diving suit, which is more like a suit of armour, his movements become limited, and although he can go deeper, he still cannot go to a depth of 600 feet.

One or two men have gone to greater depths, and returned alive, but only after very long and special preparation. In 1934 William Beebe descended in a specially built steel sphere to the very great



Aqua-lung Diver



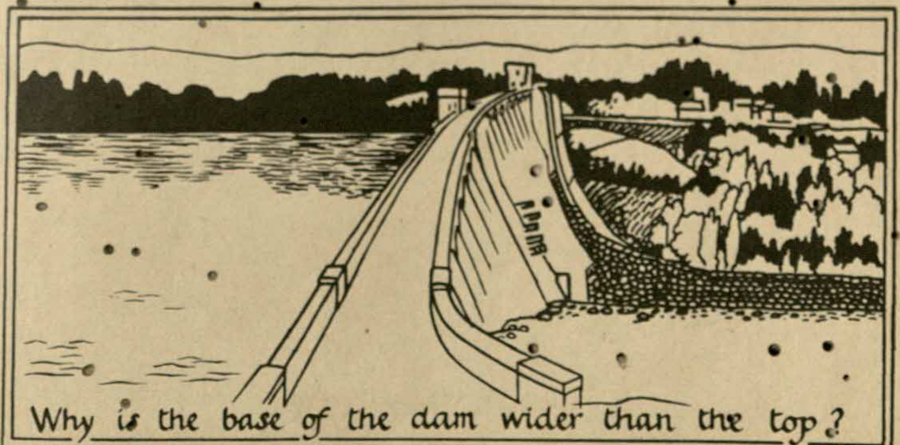
Deep Sea Diver

depth of just over 3,000 feet in the sea near Bermuda. Since then a few men have gone even deeper, but always in specially built steel spheres.

Now why do you think there is this difficulty in exploring the sea at great depths? What is the biggest danger to men at these depths which they must overcome? Do you know why submarines must not go below a certain depth in water? If you think you know the answers to these questions look at the picture of the dam. You will see that it is wider at the bottom than at the top. Why?

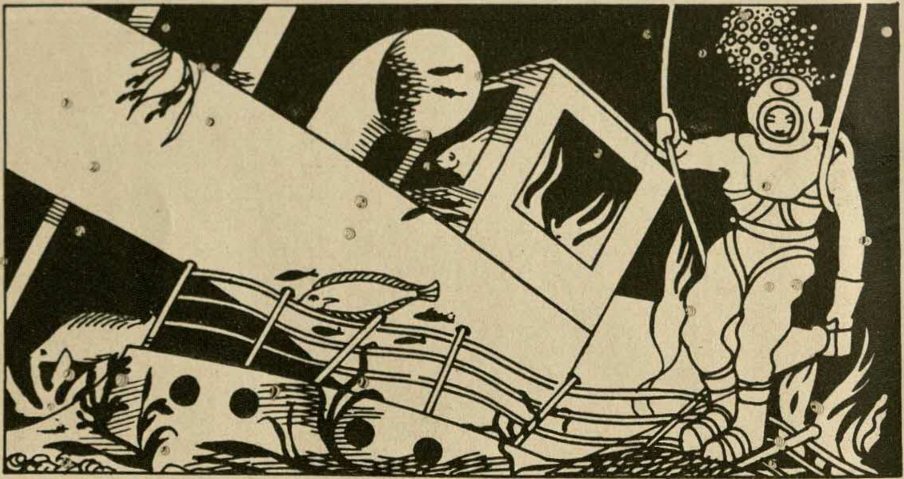
At sea-level the pressure of the air on our bodies is about 15 pounds on every square inch. If we descend into the sea to a depth of 33 feet the pressure on our bodies increases by another 15 pounds on every square inch. As we go deeper so the pressure increases. Thus, if we descend about 60 feet into the water, the pressure of the water is about 30 pounds on every square inch of us, and added to this there is the 15 pounds due to the air pressure at sea-level. This is about the highest pressure man can endure, that is, about 45 pounds on every square inch.

There are certain types of fish life that have been brought up from the great depths. Find out if you can how these fish can exist under such pressures as those found at great depths. Why are not they 'flattened' by the tremendous pressures?



Why is the base of the dam wider than the top?

WHEN airmen and mountaineers go to great heights they have to take with them a supply of oxygen. This is because as we have seen the air pressure becomes lower and as a result there is not enough oxygen for their needs. On the other hand some men work in conditions where there could be too much pressure. A diver when he descends, finds that the pressure of the water on his body increases. This increase amounts to nearly a pound for every two feet that he goes down. As the diver descends he would find breathing very difficult or impossible if it were not for the fact that this pressure by the water is balanced by the air pressure inside his diving suit. Thus, as the diver goes down the pressure of the air supplied to him must be increased. Under this greater pressure more air will dissolve in the blood than at sea-level. When the diver comes to the surface, where the pressure is much less than it was below, the blood cannot hold all this dissolved air. Bubbles form in the blood and this may have drastic results, that may even lead to death. Something has to be done to counteract this. When the diver descends the rate at which he goes down must be controlled and particularly must be the rate at which he comes to the surface. When rising he stops at various heights to allow the extra air, particularly nitrogen, that has dissolved in his blood to come out naturally in the breath and so let his blood reach a normal state again slowly. Diving bells are used for working under water too,

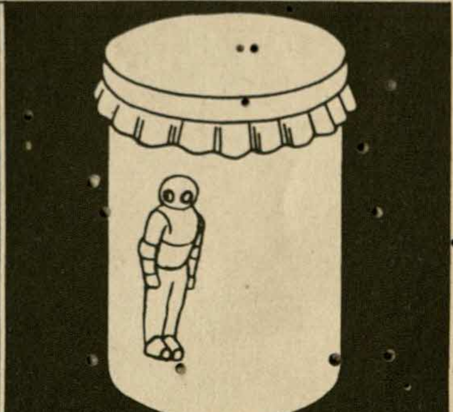


when more freedom of movement is needed than is allowed by diving suits. When the 'diving bell' is lowered into the water, the pressure of the water compresses the air inside and so rises into the bell. When the bell has been lowered about 33 feet the air will take up only half the room that it did at the surface. If air is forced through a shaft increasing the air pressure within as the bell is lowered, the water can be kept out of the bell.

Here is a toy which you have probably seen. It is often called the Cartesian Diver. Have you ever tried to make one for yourself? Using a small celluloid doll, or some such figure which must be hollow, pierce a small hole in the bottom. Now weight it with a piece of lead until it only just floats in water with the head of the figure just on the surface of the water. Across the top of the jar stretch a piece of rubber such as you can get from an old cycle tyre. This must be tied down tightly. When you press on the rubber the figure will dive to the bottom of the jam jar, and stay there until you release the pressure on the rubber. As soon as you take your hand off, the figure will rise to the top and stay there until the rubber is pressed again.

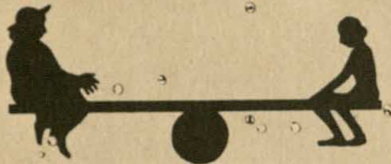
Do you know why this happens? What is the purpose of the hole in the bottom of the figure? Can the hole be in the top and the toy still work properly? We will be dealing with this again later on, and you will be able to see if your explanation is right.

Pilot with Oxygen Mask



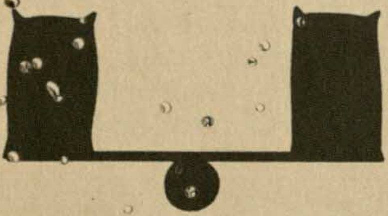
Cartesian Diver

WEIGHT—

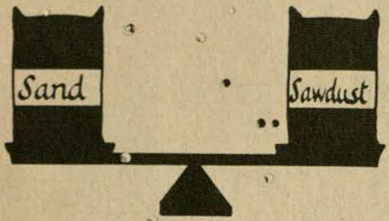


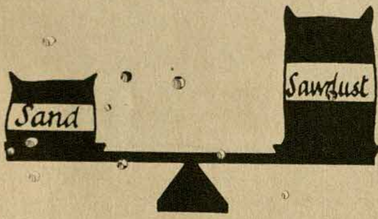
LOOK at the picture of the two girls on a seesaw. One of them is clearly heavier than the other. If they are both sitting at the same distance from the centre, which end will tilt downwards? Why?

Now look at the second picture. Can you say which end will go down? Of course you cannot, because you are not told what is in the sacks. Instead of a seesaw, let us use a simple balance.



In the third picture you see a balance with two sacks on the pans, and both of the sacks are the same size. Even now, unless we know what is in the sacks we cannot say which end of the balance will go down. We must know more about the contents of the sacks. If one of these sacks is filled with sawdust and the other with sand, which side of the balance would go down? The pan with the sack of sawdust will go up, while the pan with the sack of sand will go down. We know this from experience. When we take equal quantities of sand and sawdust, we know that the sand is heavier than the sawdust, bulk for bulk, or volume for volume. Now look at the fourth picture. Here the smaller sack is filled with sand and the larger one is filled with sawdust. The volumes are not equal so we cannot say which pan will go down and which one will go up. To compare them we must know how much room both the sawdust and the sand take up. We must know the volumes.





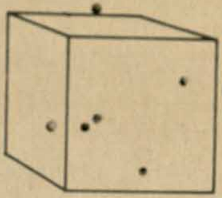
Look at the two blocks, both of equal volume and the same material. They will weigh the same. Now look at the second two blocks, one of wood and one of metal.

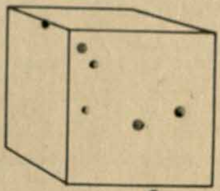
—AND DENSITY

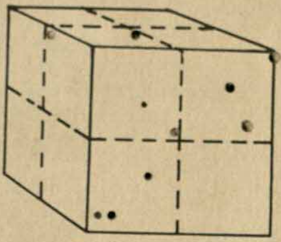
Although you know by experience that metal is 'heavier' than wood, we can see that the block of wood is larger than the block of metal. How can we compare them? The block of wood in the picture has been divided up into cubes the same size as the aluminium. The weight of the wood, which is oak, is 384 lb., while the weight of the metal, which is aluminium, is 165 lb. The weight of the oak is distributed over eight cubes, while the weight of the aluminium is distributed over one cube. Which small cube, oak or aluminium, do you think weighs more?

The weight of a unit volume of a substance is called the density of that substance. In this case although the weight of the block of oak is more than the weight of the block of aluminium, the density of the metal is greater than the density of the wood. Or as we often say, the metal is denser than the wood. To find the density of anything, we divide the weight of the substance by its volume. If a piece of iron weighs 980 lb. and its volume is 2 cubic feet its density will be 490 lb. per cubic foot.

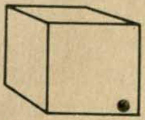
Measure the sides of a tin box or some such container and calculate its volume in cubic inches. Weigh it on a pair of scales. Now fill it level with the top with various materials such as sand, soil, and water, and weigh them. Subtract the weight of the container and you will have the weight of the material. Now you can calculate the densities of the various materials. Why would not this method be of use with lumps of coke or coal?





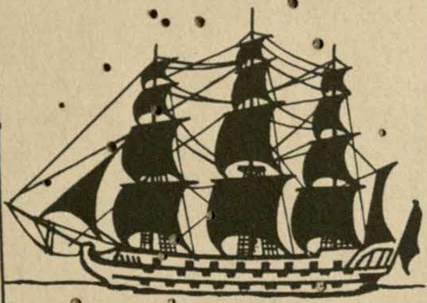


OaK
This weighs 384 lb
Each side is 2 Feet

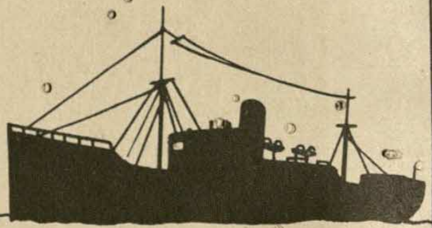


Aluminium
This weighs 165 lb
Each side is 1 Foot

A PIECE OF STEEL SINKS



Wood is less dense than water
A wooden ship floats

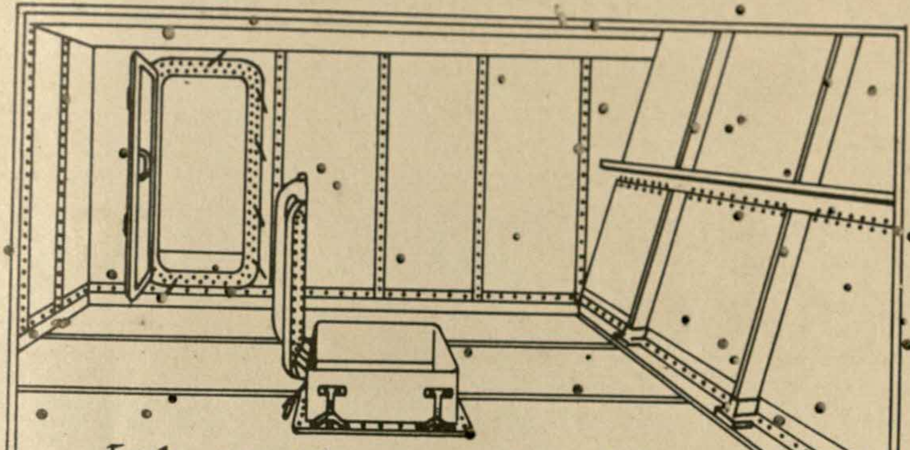


Steel is denser than water
but a steel ship floats

HOW many materials can you think of that float in water, and how many that sink? Make a list of them. Which have the greater density, those that float or those that sink? The reason that some materials float while others sink in water is the same as the reason for some things floating in air while others do not.

A piece of cork floats in water because it weighs less than an equal volume of water, and a piece of iron sinks because it weighs more than an equal volume of water. We say that the density of cork is less than the density of water, and the density of iron is greater than the density of water.

What happens to the human body in the water? Does it float, or sink? It is a little less dense than water, so part of it does stay above water level. Which part of the body depends upon the person. If a person who cannot swim gets into difficulties in deep water he will throw his arms and legs about thrashing the water, so that the rest of the body, including the nose and mouth are below the surface of the water. Have you noticed how heavy your body feels when you get out of the water? While you are in, all or nearly all of your weight is supported by the water and as you come out less and less of you is supported by the water, and so your body feels heavier.



Each compartment can be sealed separately by watertight doors and hatches

A lump of iron or steel when placed in water will sink, yet nearly all large boats and vessels are made of iron or steel today, and of course they float! Why is this possible? What is the great difference? Although the ships are built of steel, a lot of the inside building is of wood, and nearly all the space inside the ship is filled with air. Because of this the density of the whole ship including the air spaces is less than the density of water. If a ship is holed below the water line, water enters and the effect is that the weight increases. Unless it is stopped, water continues to enter, taking the place of the air. This means that the density increases until it is more than that of water. When this happens the vessel sinks. Of course, as the water enters and the density increases, the vessel sinks lower and lower in the water. The chances of ships sinking are lessened by building them in such a way that whole sections can be divided off and made watertight. A ship so divided is unlikely to sink unless several of these watertight compartments are holed at once. If only one of these compartments is filled with water, it does not increase the total weight, and therefore the density, to such an extent that the ship will sink. If we allowed water to enter and then forced it out at will we would vary the density of the ship as a whole as in the submarine.

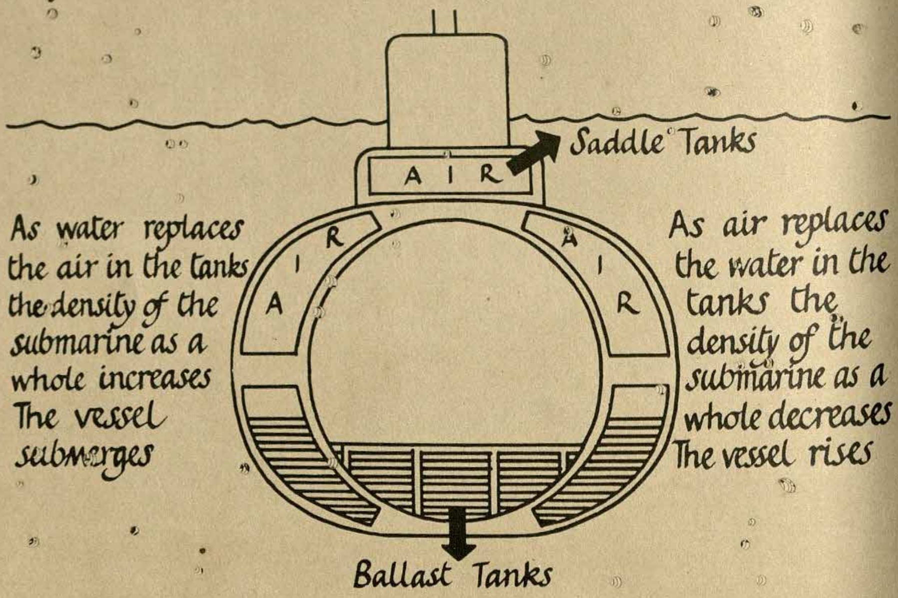
A SUBMARINE CAN FLOAT—

MOST ships that are built of steel are designed so that they float, but there are some that are designed so that they float like ordinary surface ships, and sink under control as well. They are called submarines.

You have seen that some things will float on water while others will sink. It depends upon the density of the object. That is, some objects weigh more than an equal volume of water, and others less. But the submarine both sinks and floats. Therefore at times its density must be more than at other times. How can this be so?

As with surface ships, most of the space in a submarine is filled with air. If this space, or at least part of it, can be filled with water when needed, the density can be increased in such a way that the vessel just sinks. Of course this would be useless unless the reverse could be done, and the water pushed out again when required. For diving, water is allowed to enter special tanks so that the weight of the whole submarine is increased. To surface the submarine again the water is blown out of the tanks by means of compressed air.

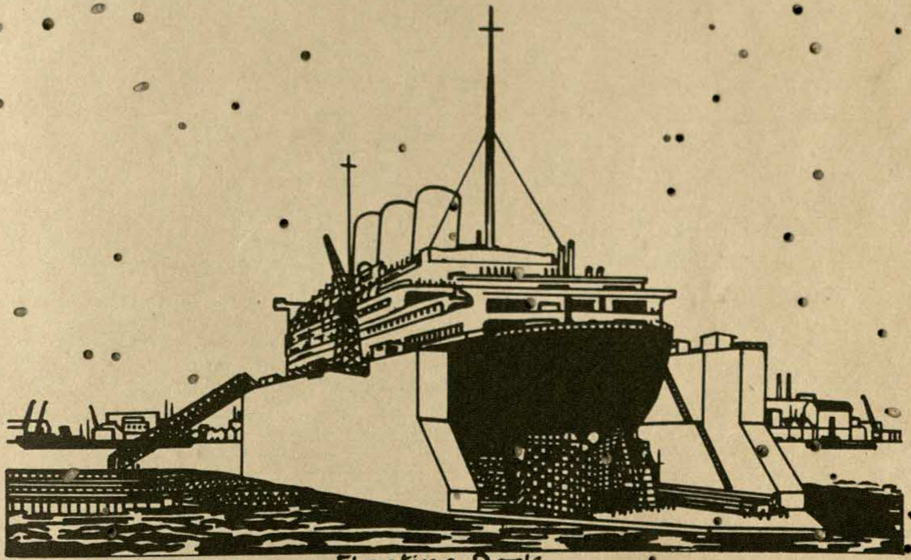
Fish can swim freely about, and vary their depth in the water. They have a 'swim bladder' which they make either bigger or smaller


Saddle Tanks
AIR
As water replaces the air in the tanks the density of the submarine as a whole increases The vessel submerges
AIR
AIR
As air replaces the water in the tanks the density of the submarine as a whole decreases The vessel rises
Ballast Tanks

as they want. When the bladder is expanded, the fish rises in the water, because its volume has become a little bigger, and as a result its weight is more nearly equal to the weight of the same volume of water. What would happen if it weighed less than an equal volume of water?

How did you explain the working of your Cartesian Diver? It is similar to the way a submarine goes up and down in water. As soon as you press the rubber on top, the pressure of your hand compresses the air a little and this forces a small amount of water into the hole at the bottom of the diver. This increases the density of the diver, and he sinks. As soon as the pressure at the top is released, the air inside the diver forces out the water, the density decreases and he rises to the surface.

One of man's very interesting inventions is the Floating Dock. As the name suggests, it floats in the water, and is used to lift great liners right out of the water so that repairs can be done to the hull, which is normally below the water line. The docks are mainly made of tanks that are generally full of water. When the water is blown out by air the dock rises in the water lifting the liner with it as it does so.

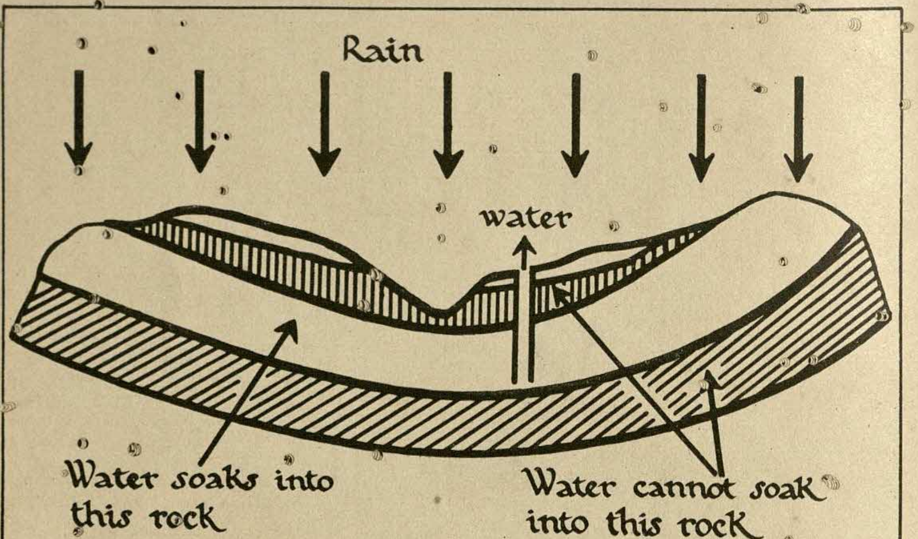


Floating Dock

SOMETIMES the supply of water for a particular district comes from an artesian well. It is only in some areas that a boring can be made, and as soon as a certain depth is reached, the water will gush out. Look at the picture and follow the path of the rain.

When rain falls some of it runs along the surface of the ground until it reaches the nearest stream, the stream flows to the river, and then on to the sea. But some of the rain water soaks into the soil. If the upper layers of the soil will allow it, the water drains through until it reaches a layer of rock. Water can pass through some types of rock but not all. But sometimes, as shown in our picture, water will seep below rock to the layer which is underneath. If this layer is of such a nature that the water can soak into it, the layer becomes saturated. The level of the collecting water rises until an outlet is found, such as a spring. You may remember that we talked about springs before. When rock covers a saturated area, it is reached by boring a hole right through the rock, and if the boring is below the natural water level in the area, then the water will gush out of the hole made for it.

If water is poured into a "U" shaped tube it rises in both arms of the tube to the same level. It does not matter into which arm the

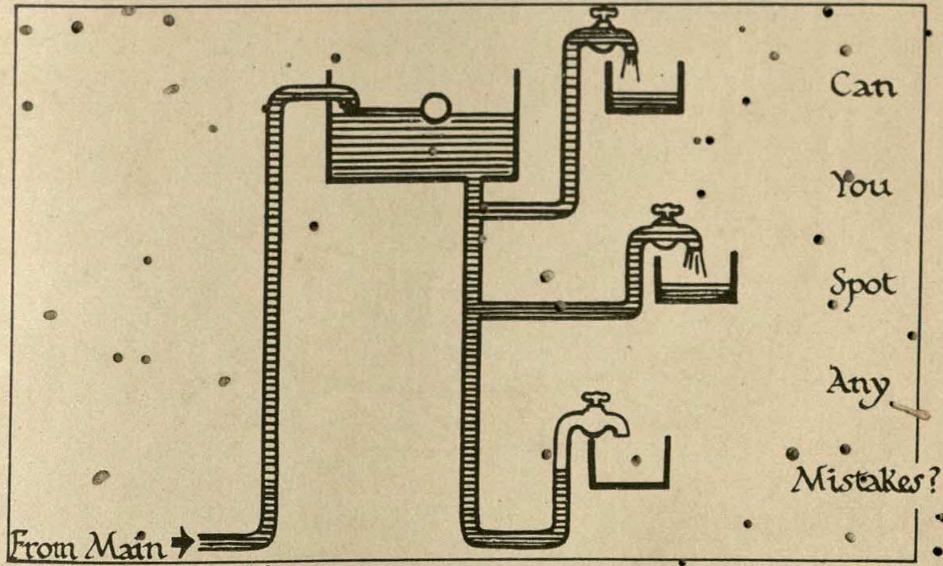


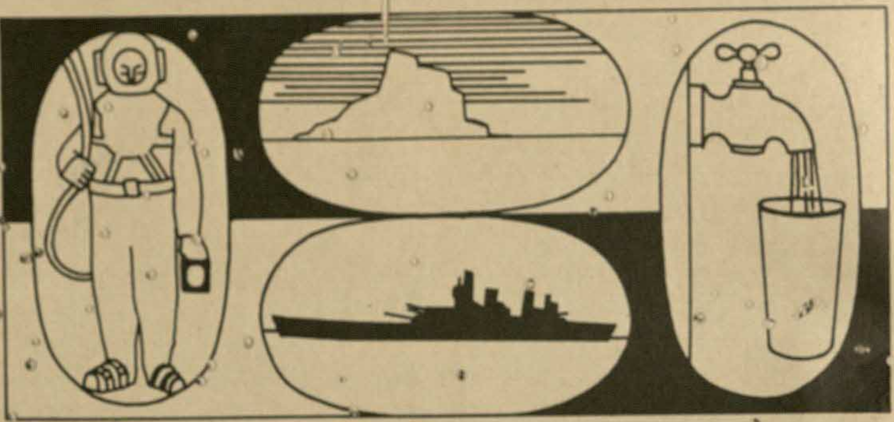
water is poured. That is, of course, provided that both arms are open to the air. Water always tends to have its open surface level. But what would happen if water was poured into one of the arms, whilst the other arm was corked up?

In your home where is the supply tank for your water? Is it in the roof? How do you think the water reaches your tank? You already know how water comes to you from the river, through reservoirs. These reservoirs are generally on high ground, in fact they are constructed so that they are higher than the level of your house. The water flows down from the reservoirs, through the mains, and rises to your tank in the roof. This is similar to our first "U" shaped tube. But if for some reason the reservoirs are not high enough, then water towers are built and the water has to be pumped up them to the top. From the water towers it passes through the pipes into the tank in your home.

An arrangement, called a ball valve, is used on the household tank to prevent it overflowing. We will be talking about this later.

Here are some drawings of taps in a house. Can you spot any mistakes?



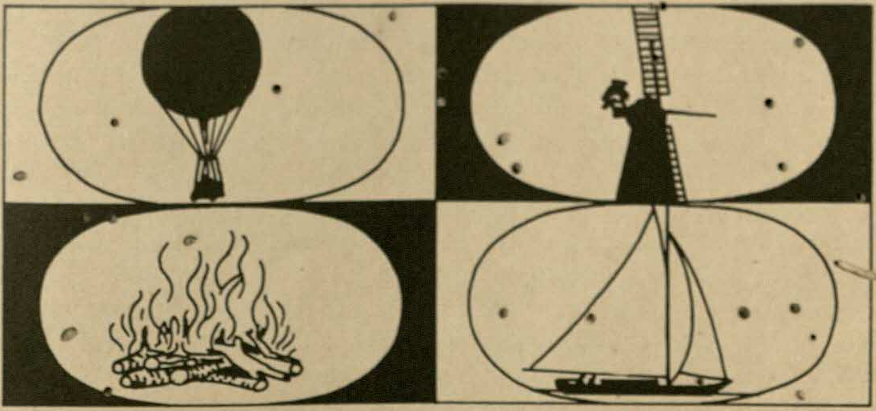


ON these pages there are two exercises. Copy them into your record book, filling in the gaps, and putting in the pictures. If you are not certain which word to use, put it in with a pencil first, and when you have checked that it is right you can ink it in.

"Water, which covers such a large part of the earth's surface, is just as necessary for life as air. Although we generally see it as a liquid, in cold weather we see it as —— and ——. Water when —— turns into a gas and this is called ——. —— is invisible and when a kettle is boiling, the cloud we see near the spout is made up of very small drops of ——. When water freezes it —— so that the ice that is formed takes up more room than the water. This —— when water freezes causes burst pipes during the winter time. Another result of this expansion is that ice is less —— than water, and the effect of this is seen when ice —— on water. Very large pieces of ice, called —— are a real danger to shipping. Water will dissolve many things. Our drinking water goes through many stages from the time it fell to the ground as —— until it comes out of our taps. One of the most important ways of moving about the world is by boat. Although we would expect a wooden boat to —— modern vessels are built of ——. These float because the —— of the boat as a whole is —— than the density of water. Divers can only descend a certain distance because of the very great —— of water."

—FOR YOUR RECORD BOOK

"Air, which is all about us, is necessary for us to ——. Yet we take it for granted, probably because we cannot see it. But we know that it is there because sometimes it moves very —— and causes things to move with it, such as the sails of a ——. It blows the trees about, and can be a nuisance at times. On the other hand it is made use of to move —— —— on water, and to keep kites and —— up in the sky. Air is a mixture of several ——. They are oxygen, which is needed to keep us ——, and ——. —— dilutes the oxygen and so stops the lungs and fires from getting too much oxygen. —— is also necessary for plant life. Inert gases, although they only make up a small part of air are very necessary and useful to us today. —— —— is also present in the air, and causes us difficulties in the form of mists and fog. There is, also, carbon —— which is used by ——. Air is present above the earth's surface, but gradually gets —— the higher one goes. At the —— of high mountains such as Everest, there is very little air, and —— have to carry their own supply. Because there is air many things can rise up in it from the ground. Some of them, like ——, can rise in still air, but some need moving air to keep them up. Some of the things that need moving air are ——, —— and ——. When air becomes warmed it becomes less ——, and rises, —— air flows in to take the place of the air that has risen. In this way, air circulates in a room."



DOES it take longer to boil a kettle full of water than it does to heat a thin piece of metal, such as a darning needle, to red heat with the same gas burner? Probably you have never seen these two things done at the same time, but you will know that it takes several minutes for the kettle of water to boil, yet the needle will become red hot in a few seconds. Try it for yourself, but be careful to hold the needle in a pair of tweezers, so that you do not burn your fingers. The kettle of water needs a great deal more heat to make it boil, than the needle needs to make it red hot. But can you say which is at the higher temperature? Although the needle needs less heat than the kettle of water, the metal is at a higher temperature. In fact you could use the boiling water to quench, or cool, the hot metal.

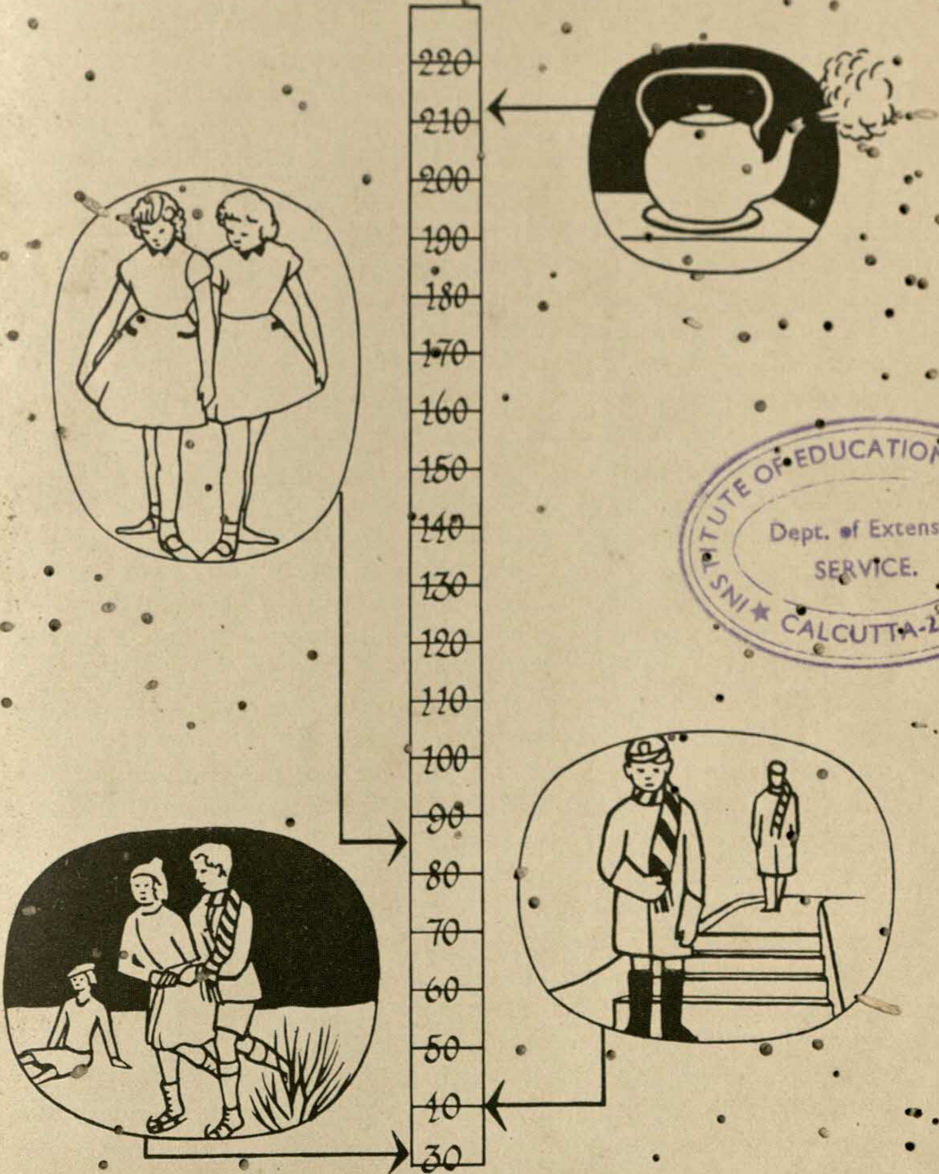
The instruments used to measure temperature are called thermometers. There is not a great deal of difference between the temperature of the air on a pleasantly warm day and on an unpleasantly chilly one. On a warm day, a slight rise in temperature and the weather becomes unbearably hot, while on a cold day, a slight fall in temperature and it becomes bitterly cold. Just to give you an idea of how close these temperatures are, look at the picture. Melting ice is given the temperature of 32 degrees, and boiling water 212 degrees; we will learn more about this later. You will see that the usual temperatures of summer and winter lie between 30 degrees and 90 degrees.

At first it may appear that the skin is a good judge of temperature. In winter when you go from a warm room to an overheated one, and then to a cold room, you immediately notice the difference. But if you keep tropical fish that have to live in water at a constant temperature, you will have noticed that the water feels warm in winter and cool in summer, although its temperature has not changed.

Again on a cold day if you pick up an iron shovel and a piece of wood that have been lying out of doors for some time, and are therefore both at the same temperature, one feels much colder than the other. In exactly the same way, in the summer when both the iron and wood have been lying in the sun, the iron feels much hotter than the wood. Why do you think this is? Do you think that the skin is a good guide to the temperature of things?

—TEMPERATURES

The Numbers give the temperature in Degrees Fahrenheit



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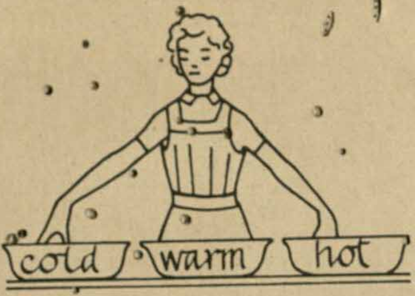
Dept. of Extension
SERVICE.
CALCUTTA-27

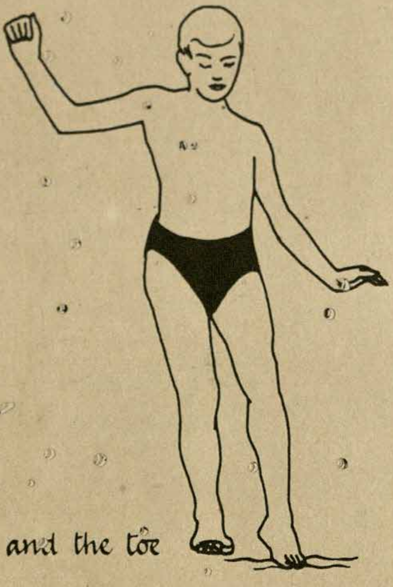
YOUR HANDS—



HERE are one of two simple things that you can do to see just how reliable your hands are as a guide to measuring temperatures. Arrange three bowls of water as shown in the picture. In one put hot water, in another warm water, and in the third put cold water. First put your right hand into the bowl of cold water, and your left hand into the bowl of hot water. After a moment or two take out both your hands and put them into the bowl of warm water. What do you notice?

Testing water with elbow

Now for the second experiment. This time use only the bowls with the hot and the warm water in them. To the hot water add some cold water, just a small amount at a time, and test it with your hand until you think that both bowls contain water of equal temperature. With a thermometer measure the temperature of the water in each bowl, and see how nearly correct you were.



and the toe

When a baby is to be bathed, the mother may test the temperature of the water with her elbow. This, to a person who does it regularly, can be a good guide to the temperature, for a baby's bath must not be too hot. You, too, will have tried the water in the bath, or even in the sea, by dabbling your toes in the water.

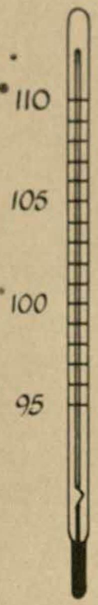
—AND THERMOMETERS

Some people who work a lot at one particular temperature become quite expert at judging whether the temperature has risen a little, or fallen a little below their normal working temperature.

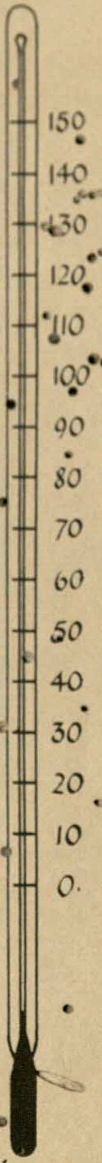
Although there are many types of thermometer, there is one type of which you all ought to know. That is the clinical thermometer. Have you ever held one in your hand and examined it? The two diagrams are of thermometers. One is the clinical thermometer, and the other is a thermometer of the type that is used to measure the temperature in a room. Both of them are made of glass with a thin column of mercury running from a fairly large bulb at one end. What do you notice about the scales of each? Why do you think there is a narrow part, or constriction as it is called, in the stem of one of them?

The thermometer that the doctor uses, the clinical thermometer, has an accurate scale marked in fifths of a degree, it starts at 95 degrees and goes up to 110 degrees. Can you say why?

What would happen if you tried to wash a clinical thermometer in boiling water? (The temperature of boiling water is 212 degrees.)



Clinical Thermometer



Ordinary Thermometer

TWO TEMPERATURE SCALES

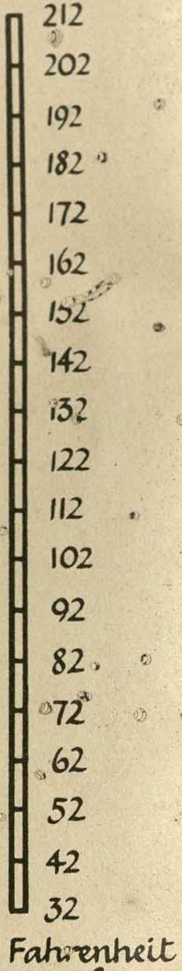
THE scale on a clinical thermometer is marked from 95 degrees to 110 degrees Fahrenheit. Some thermometers, those used by scientists, are marked with a different scale, the Centigrade scale.

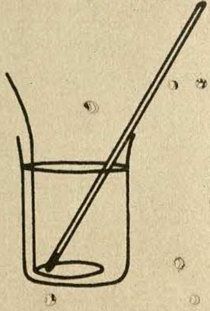
The Fahrenheit scale was suggested by a man of that name. He experimented with a thermometer in a freezing mixture of ice and salt and the lowest reading he obtained he called zero, or mark 0. From this he continued experimenting until he finally obtained a scale that made the boiling point of water 212 degrees. On this scale the freezing point of ordinary water became 32 degrees. This is the scale used today, and when writing a temperature in Fahrenheit we shorten, or abbreviate, the words, so that the boiling point of water would read 212° F.

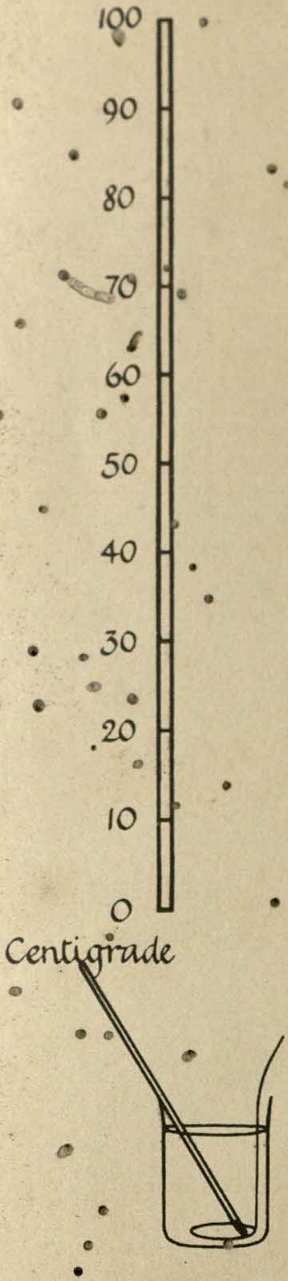
Another scale of temperature used over nearly all of the Continent and by all scientists was devised by a man named Celsius. On this scale the freezing point of water is 0 degrees Centigrade, or 0° C. for short. The boiling point of water is 100° C.

There is another scale, called the Réaumur scale, but it is hardly ever used in this country.

When the temperature is known in degrees Fahrenheit, how can we find what the reading would be on a Centigrade thermometer? It can be done by arithmetic, but we are going to make a drawing to find out. The diagram shows you how to do it. Draw two lines of the same length down a page. At the bottom of each line make a mark to represent the freezing point of water. On the Centigrade scale it will be 0 and on the Fahrenheit scale it will be 32. At the top of the two lines, mark two more







points for the boiling point of water, on the Centigrade it will be 100 and on the Fahrenheit 212. Divide the Centigrade scale into 100 divisions, and the Fahrenheit scale into 180. To convert 50° C. to degrees F. we just read across the two scales, and we find it is 122° F.

Make a copy of the following passage, converting the temperatures given in Centigrade to Fahrenheit.

"Although two familiar temperatures are 0° C. and 100° C., the first being the freezing point of water, and the other the boiling point of water, we ourselves are concerned with a much smaller range of temperatures. We feel cold when the temperature is 5° C. and warm when the temperature is around 19° C. to 20° C. On a really hot day in summer the temperature may rise as high as 30° C., although this does not happen often. This means that most of our life is spent within a temperature range of 0° C. to 20° C."

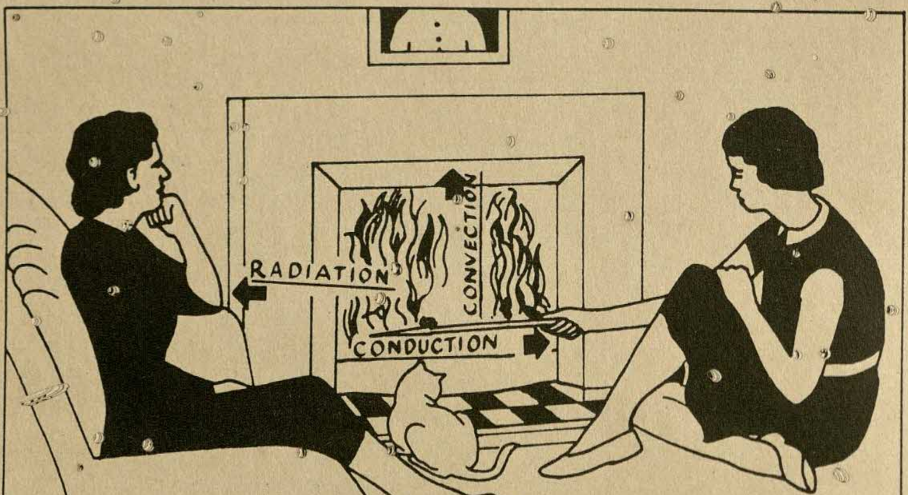
Let us compare the temperatures on the two scales. For this you will need two thermometers, one with a Centigrade scale and another with a Fahrenheit scale. Put some hot water into a beaker or can and stir it. One of you can read the temperature on the Fahrenheit scale and another can read the temperature on the Centrigrade scale. Now look at the scales in this book. Do your readings agree with the scales? They may not be quite exact but should be very close. Now let the water cool for a while, and then stir it again and take further readings. Do this several times, comparing your readings with the scales given here.

HEAT CAN TRAVEL—

WE all like to see a big fire in the winter, and know just how inviting it can be, especially if unpleasant draughts can be stopped. But as you know some fresh air must get into the room so that the fire can burn properly. Also, of course, unless there is some fresh air, the room soon becomes an unhealthy place.

In a warm room the air circulates round, because it is heated by the fire, becoming less dense than the cold air which is coming into the room, and so it rises above the cold air. Gradually, because of the movement, all the air in the room warms up, and it warms the room. This movement of the air is known as a CONVECTION current.

If a poker is left in a fire for any length of time the end in the fire becomes red hot, sometimes even white hot. But the other end remains a dull metal colour. Yet if you were to touch it with your hand you would find that even this dull end had become very hot too, you might even burn yourself. Why is it that this end of the poker gets so hot as well? You will find also that if a metal tablespoon is left standing in a saucepan of boiling liquid, not only the spoon end, but the handle becomes too hot to hold. Heat is passed from the hot end to the cooler end without any movement as in the case of convection currents. The heating of the poker and the spoon are examples of

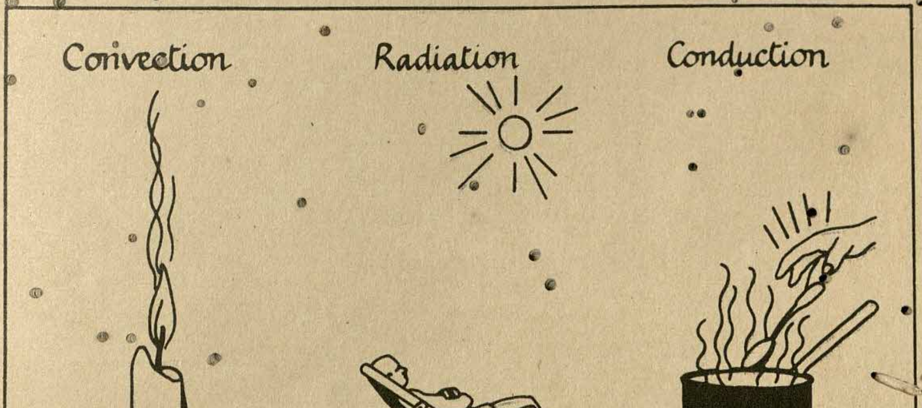


CONDUCTION. Can you think of any other examples of heat being transferred by conduction?

Pets in the home, such as the dog and cat, always enjoy a fire, and will sit as close as they can, especially in the winter, even if they have to move away for a while to cool down. In the winter when it is cold, most people like to pull their chairs up to the fire, and to warm themselves in front of it. The convection currents are not enough to warm them, so how is it that they get warm? They do not get hot by touching the fire, so there is no conduction. A hot fire sends out rays of heat, and these rays do the warming. Not only do fires radiate heat, any warm body can radiate heat. We use the term RADIATION in connection with this type of heating. Again there is no movement of anything. The heat comes straight from the fire to the object it first meets, be it cat, dog, or human being. Radiated heat does not warm the air, but passes through it.

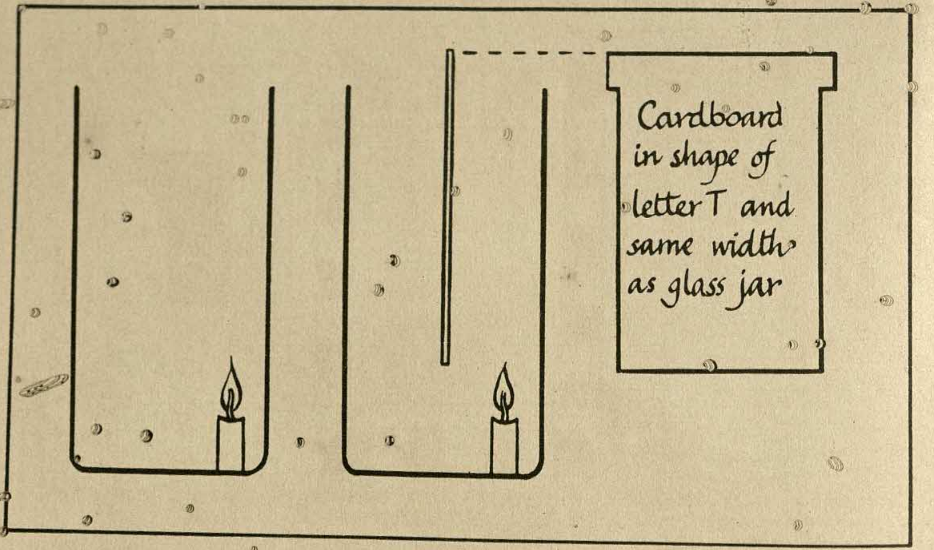
So we see there are three ways in which heat can travel:

1. Convection
2. Conduction
3. Radiation



YOU now know that hot air rises because it is less dense than cold air, but have you actually seen the hot air rise? When you experimented with a lighted candle in a glass-fronted box with the two chimneys, you saw that the current of air caused the smoke to move through one of the chimneys, but you did not see the moving air! Here is another experiment for you to do, using a lighted candle.

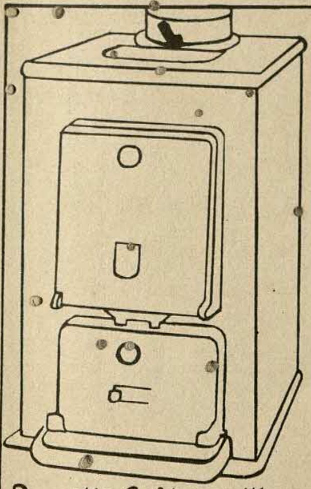
Stand a lighted candle, a short length is best, at the bottom of a glass jar or lamp chimney. The candle must not be in the middle of the jar, but a little to one side. You may find it easier to put the candle in position first and then to light it with a wax taper. Watch the flame carefully, does it burn with a clear flame, or a smoky one? It is quite possible that the flame will die right down and go out altogether after a while. Why do you think this happens? If it goes out, relight your candle, and put a piece of cardboard cut in the shape of a letter "T" into the top of the jar, so that the jar is now divided into two parts. Look at the picture here. What has happened to your flame now? Is it burning more brightly? Hold a piece of smouldering paper, or rag, over each of the openings in the jar in turn. Can you say which way the air current is moving? Why does the cardboard make the difference?

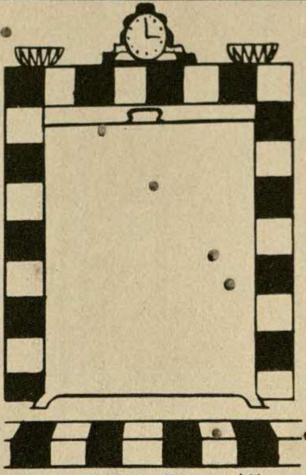


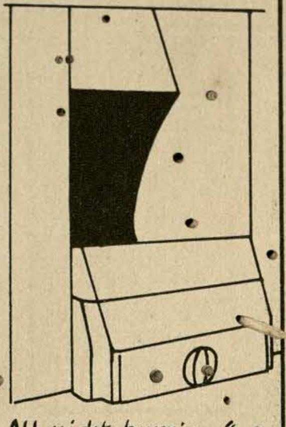
—CAN BE CONTROLLED

When a fire is burning well, the air near it quickly becomes warm and a strong convection current is set up. Cold air flows in to replace the rising hot air, but most of this passes over the fire, up the chimney. Can you remember how we said that a fire could be made to burn more brightly by increasing the air supply at the bottom of the fire? We talked about the domestic boiler. To make the boiler burn up we open the draught control at the bottom, and open the damper above the fire. With an open fire, in an ordinary room we can only open the draught control at the bottom of the fire so that it burns up more brightly; there is no control above the fire. There is nothing to prevent the cold air entering a room and passing over the fire instead of through it. Sometimes the air can be made to pass under and up through the fire by stretching a newspaper across the front of the fire, but this is very dangerous, and a much better method is to use a metal sheet which can be fixed into position, left for a few minutes, and then removed, when the fire has burnt up.

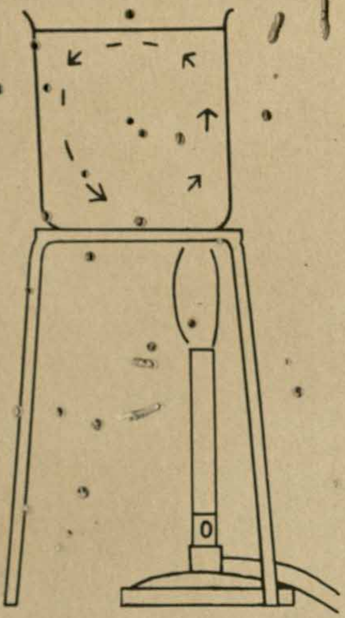
Nowadays we hear a lot about "All night burning fires". Can you suggest how they can be made to burn all night, without attention? Why are they fitted with a front plate of metal to close over the front of the fire?


Domestic Boiler with damper + draught control


Household Fire with sheet of metal in front

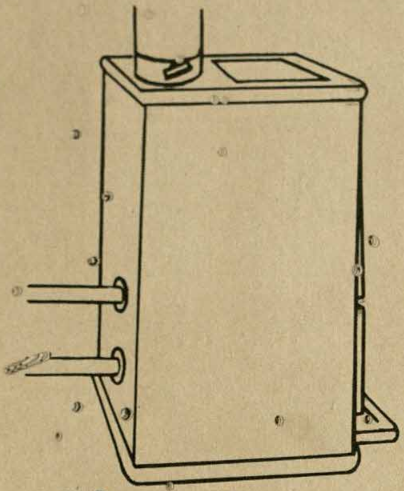

All night burning fire

CONVECTION CURRENTS—



WE have said that when air is heated it becomes less dense and rises above the cooler denser air. This movement cannot be seen, but we have shown that there is movement when we did the experiments with the smouldering rag. We watched the movement of the smoke. Do you think that there is any movement in water when it is heated? Water is free to move in the same way that air is, so there is no reason for it to behave any differently. But we must remember that water is much heavier than air. Let us make an experiment.

Fill a glass beaker, or jar with cold water, and as carefully as you can drop two or three crystals of permanganate of potash into it. They should fall to the bottom of your jar. Using a small flame, a candle will do, heat your jar gently at the bottom, and a little to one side. Now what do you see? Can you explain why it is happening? From this experiment what can you say about the density of warm water and the density of cold water?

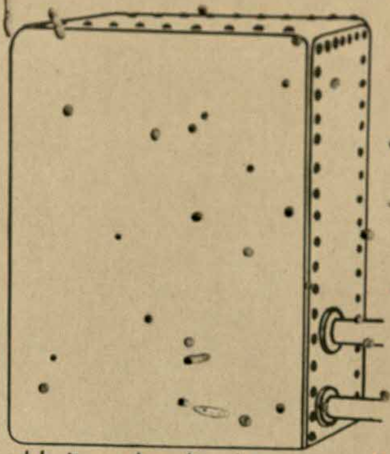


Domestic Boiler

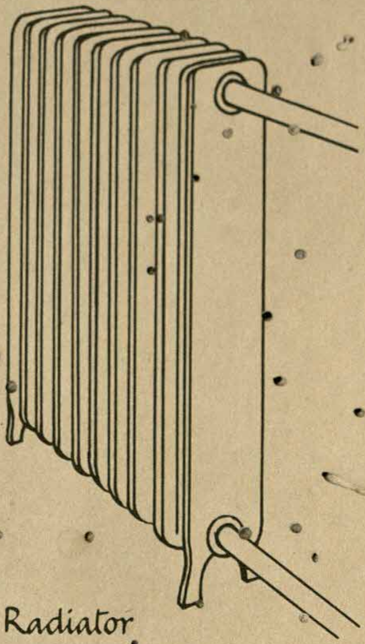
Hot water rises above cold water because it is lighter, or as we sometimes say the cold water pushes up the hot water. The fact that when water is heated it becomes less dense and rises above the cold, denser water is made use of in hot water systems such as you may find in your own home. We will say more about the hot water system later, but meanwhile here is something for you to do now. Look at the pictures of the domestic boiler, the hot water tank and the radiator. Not all the pipes are shown, but only those by which hot water enters and the cooler water leaves. Can you say which pipe is which? If there is a radiator in your classroom feel it, and see if you are right. If you have a hot water system in your house you can check the pipes there too.

When you heat a thin liquid like water convection currents are easily set up and the liquid warms up all the way through quite quickly. But if you were heating a thick liquid, such as porridge, or custard, or even thick soup, and you did not keep on stirring it, it would soon burn at the bottom of the saucepan yet at the top of the saucepan it would be quite cool. Can you explain this?

A coffee percolator makes use of convection currents. Water heated in the percolator rises up a central tube attached to a concave disc at the bottom. The water strikes the glass at the top cover which spreads it over the coffee container. After percolating through the coffee it drains back into the pot.



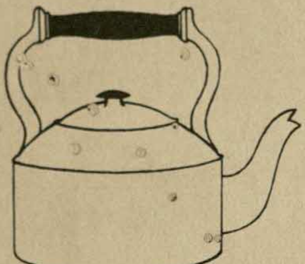
Hot water tank



Radiator

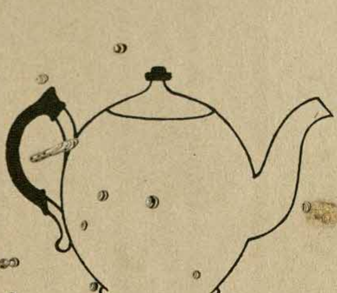
GOOD CONDUCTORS—

Do you help your mother in the morning before going to school by fetching coal or coke from the outside? If you do it regularly, winter and summer, you will have noticed how cold the metal bucket is in the winter. If you use a metal shovel too, you find that it is just as uncomfortable to hold. How much better it is to hold a shovel with a wooden handle. If a piece of metal and a piece of wood are left out in the cold so that they are at the same temperature, the wood feels less cold than the metal. If you ride a bicycle you will know that the metal handlebars will feel much colder in winter than the rubber grips. Why do these different substances, all at the same temperature, feel so different?



Metal is a good conductor of heat. That is, when your warm hand touches the cold metal, the metal quickly conducts or carries away the warmth. More so than the wood does. Hence the difference. So we can say that metal is a good conductor while wood is a poor one.

There is another term used for bad conductors of heat, we can say instead that wood is a good insulator. Generally speaking most metals are good conductors while such things as wood, wool, cotton and the gases are good insulators.



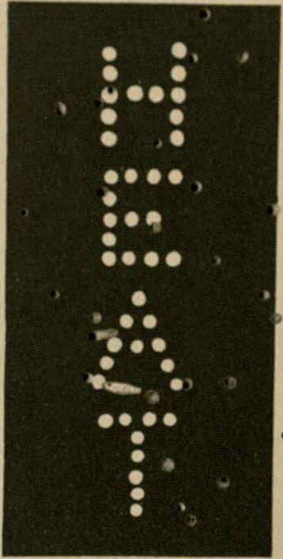
There are many examples of good insulators being used as a protection against heat, as well as cold. Kettles, saucepans and metal teapots have plastic or wooden handles for this reason. Can you think of any others?

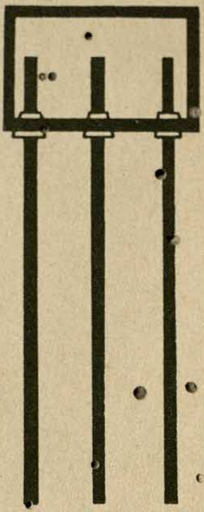
Here are two things for you to do. First of all knock some large headed nails into a fairly thick piece of wood. Over the wood paste some white paper, and let it dry. When it is completely dry, play a flame over the paper, or hold it near a flame. What happens? Can you say why?

Now try the second experiment, to see if all metals are equally good conductors of heat. Use various rods of such metals as iron, brass, copper or aluminium, and see that they are all the same length and diameter. We also need a tin can which has previously had holes made in it. Fix the rods into these holes so that there is about an inch of rod inside the can. Look at the diagram to see how it is done. If you have them, use rubber bungs to secure the rods, then the whole will be watertight, but corks will do. Now coat the rods on the outside of the can with wax. When you have done this, fill the can with boiling water and watch the wax on the rods. The rods inside the can become hot, and as the heat is carried along them outside the can, so the wax will melt. After a time it does not melt any more. You will be able to judge fairly easily which of the metals are the best conductors of heat by the distance the wax melts along the rods.

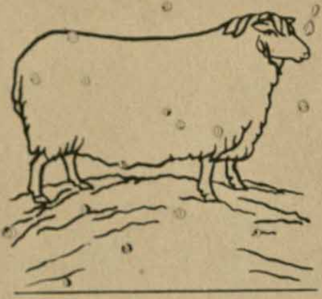
Sink a small piece of ice in a tube of cold water by tying it to a piece of lead. Gently heat the water at the top of the tube until it boils. Even after the water has been boiling for some time the ice remains unmelted at the bottom of the tube. Water is a bad conductor of heat.

When teeth are filled, a mixture or amalgam of silver and mercury is sometimes used. If only metal fillings were used, when we drank hot liquids heat would be conducted quickly to the sensitive inner parts of the tooth causing great pain. Therefore an insulating lining is put into the cavity before the metal filling.

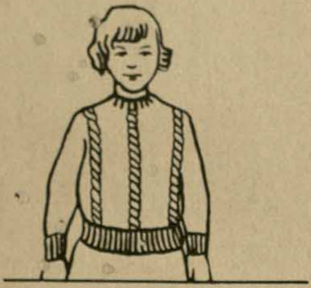




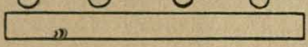
WOOL FOR WARMTH—



DURING the cold weather, we want to avoid losing any more heat than is absolutely necessary. The heat may come from a fire used to warm a room (we shall deal with this later), or the heat may come from our own bodies. Perhaps for our own personal comfort bad conductors, or as we ought to say good insulators, are more important than good conductors. As you know, one of the best materials to wear to keep you warm in winter is wool. It is a good insulator, but do you know why? Wool, such as is used to make knitted jumpers and jerseys, and woollen materials, has a lot of air, especially warm air from our bodies, trapped among the fibres. Air itself is a good insulator, and so the warmth stays in, keeping you warm. The important point is that when air that is free to move is warmed, because it is less dense it is forced up by the cold air, which then takes its place. Heat is thus lost by convection. But if as in the case of wool, the air is trapped and no heat is lost by convection then the material is a good insulator. Can you think of any other fabrics that are good insulators? What kind of material are your winter night clothes made of for instance?



We have said that air is a good insulator, this is true of all gases including steam. Do you happen to have an electric hot-plate in your home? If you have you may have noticed how water behaves when a saucepan boils over. In any case, you can do a little experiment for yourself using a gas burner and a piece of sheet iron. Heat the iron until it is really very hot. Now let one

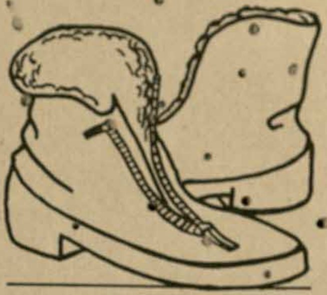


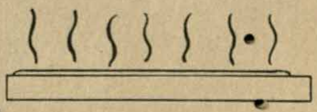
The drops of water are insulated by steam or two drops of water fall on to the hot-plate. Watch closely, and you will see that the water does not evaporate away at once. It breaks up into a lot of little droplets which seem to run all over the hot metal. Look along the level of the metal plate and you will see that there is a gap between the droplets of water and the hot metal. When the water comes into contact with the hot metal, the water nearest to it turns to steam, and that is why there is a gap. You cannot see it, but the steam is there. This steam protects the rest of the water from the heat. Steam is a good insulator, and so it takes quite a little time before all the water evaporates away.

Allow your metal plate, or sheet of iron to cool down a bit. Then drop some more water on, and you will find that if the temperature is low enough, the water will spread out over the warm metal and evaporate right away. What can you say about this?

Have you heard of the haybox cooker? When food needs long, slow cooking, this can be used. The food must be partly cooked first and when hot put into a metal container which stands inside a wooden box which is entirely lined with tightly packed hay. Loss of heat is slowed down because there is a large amount of trapped air in hay and therefore it is a good insulator.

Another example of warm air being trapped just as air is trapped in wool and the hay, is in the Eskimo's igloo. Inside the air becomes warm and because it cannot escape as it does in our houses, the warmth is kept inside.





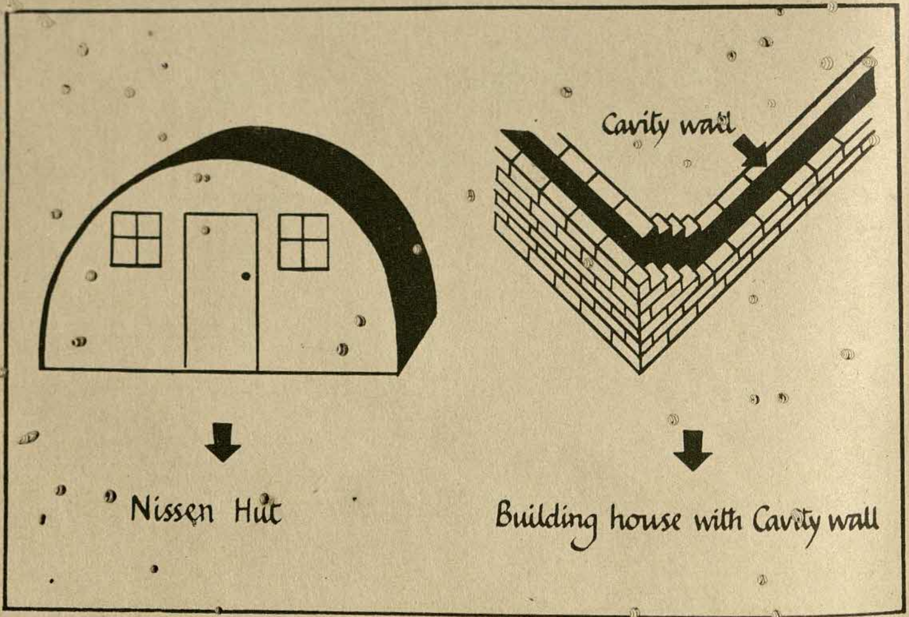
Warm Metal Plate

The water spreads over the plate and evaporates

COOL IN SUMMER—

WE want to keep our bodies warm in cold weather, and for the same reason we try to keep our houses warm too. Of course, we like to keep cool in the hot weather as well, and so we build our houses accordingly. An ideal house is warm in winter, and cool in summer. But not all of our houses are so. Imagine how the temperature must vary in a house that is built of metal. Fortunately there are very few of this type. Most of our houses today are built of brick. This is a good insulator. Concrete, too, is a good insulator. That means that houses built either of brick or concrete do not let much warmth escape through the walls in winter, and in the heat of summer, they stop too much heat being conducted through from outside.

So much then for the walls of our houses, but just to insulate the walls is not enough. What about the roofs of our houses? There are several ways of roofing a house. Thin slate may be used, or thicker tiles. Sometimes a house is tiled, and underneath the tiles it is close-boarded with wood. Quite a lot of houses have a layer of felt as well under the tiles. Then of course there is thatch. Thatching is done with

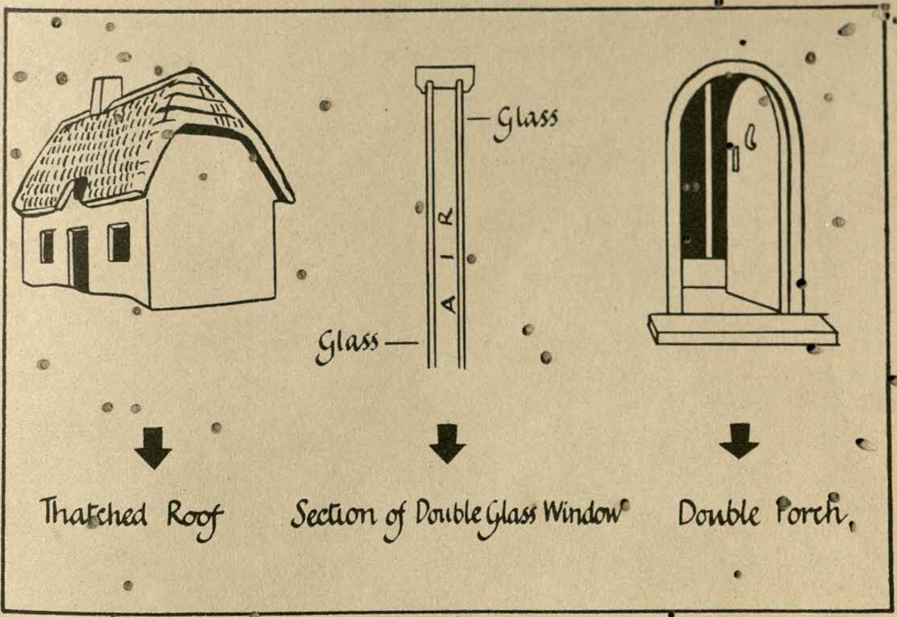

Cavity wall
Nissen Hut
Building house with Cavity wall

reeds, or straw, and with both there are pockets, or channels, in which there is trapped air.

Many houses today are built so that they have the outer walls in two parts. Instead of a solid wall, two thin walls are built, and between them there is a space filled with air. These are called "Cavity Walls". What are the advantages of cavity walls? In some countries where it is extremely cold in winter the space between the outer walls is filled with wood shavings, or sawdust, and now other materials are being tried out.

In winter you may have noticed how quickly a warm room loses its warmth in the early morning when the curtains are drawn back. Also how the opposite happens in summer when we draw our curtains on a hot sunny day to cut down the amount of heat coming into the room. Loss of heat in this way is cut down in the very cold areas by having double glass windows, the space between the glass being air filled, and air is a good insulator.

Make a drawing of your own house, in your record book and underneath list the building materials that were used to insulate it.

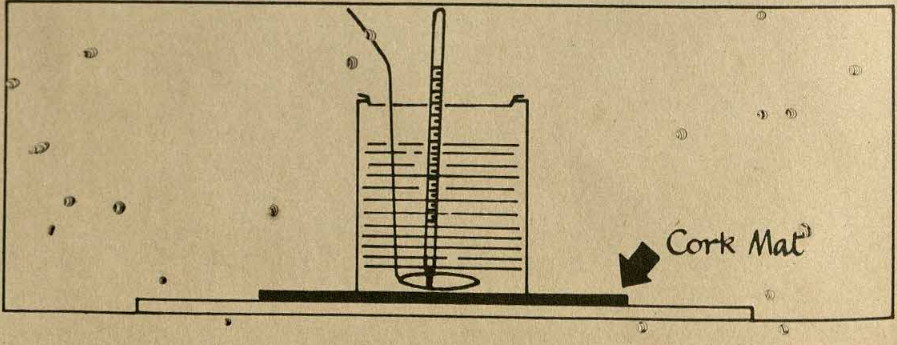


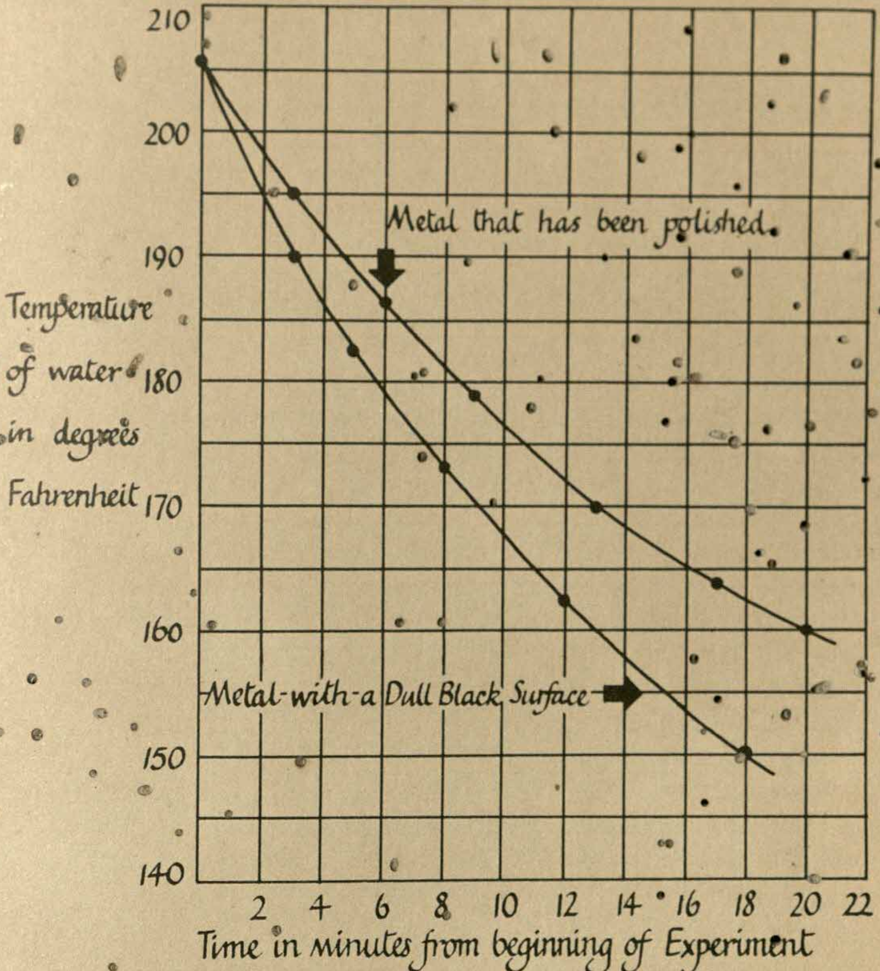
HERE is another experiment for you to do. You will need two cans of the same size with lids. Make a hole in each lid just big enough to take a thermometer, and a second hole to take a stirrer. Polish one of the cans until it is as bright and shiny as you can get it. The other can you must hold in a candle flame, or any smoky flame will do, until the whole of the outside is covered with a film of soot. When the two cans are ready, stand them on a piece of cork, and make certain that they are not in any draught. Fill them both with boiling water.

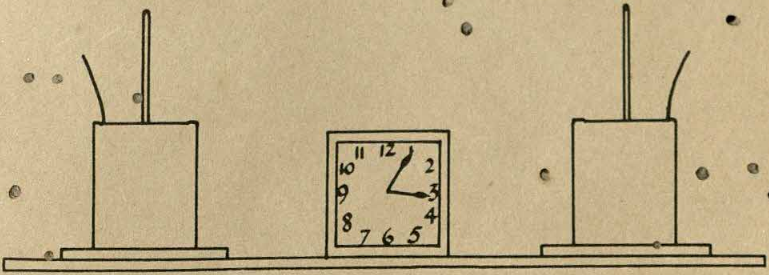
Stir the water in the cans all the time and take readings of the temperatures at two or three minute intervals. You will notice straight away that the reading on one of the thermometers is falling faster than on the other. Which can of water is losing its heat faster, the water in the shiny can or the water in the dull one?

On the opposite page there is a diagram. You will see that above the time in minutes, from the beginning of the experiment, is the temperature recorded at that time. On squared paper copy the diagram, but put in your own temperature readings. When you have finished draw a smooth curve through the points you have marked. You will then have a graph similar to the one shown. Can you explain what a graph is, in your own words? What do you notice about the slope of the lines as the temperature falls? Why are the two graphs not exactly the same?

Nearly all the loss of heat by the water has been through radiation. Which type of surface is the best radiator of heat, a dull black one, or a shiny one?




Temperature of water in degrees Fahrenheit
210
200
190
180
170
160
150
140
Metal that has been polished.
Metal-with-a Dull Black Surface
2
4
6
8
10
12
14
16
18
20
22
Time in minutes from beginning of Experiment

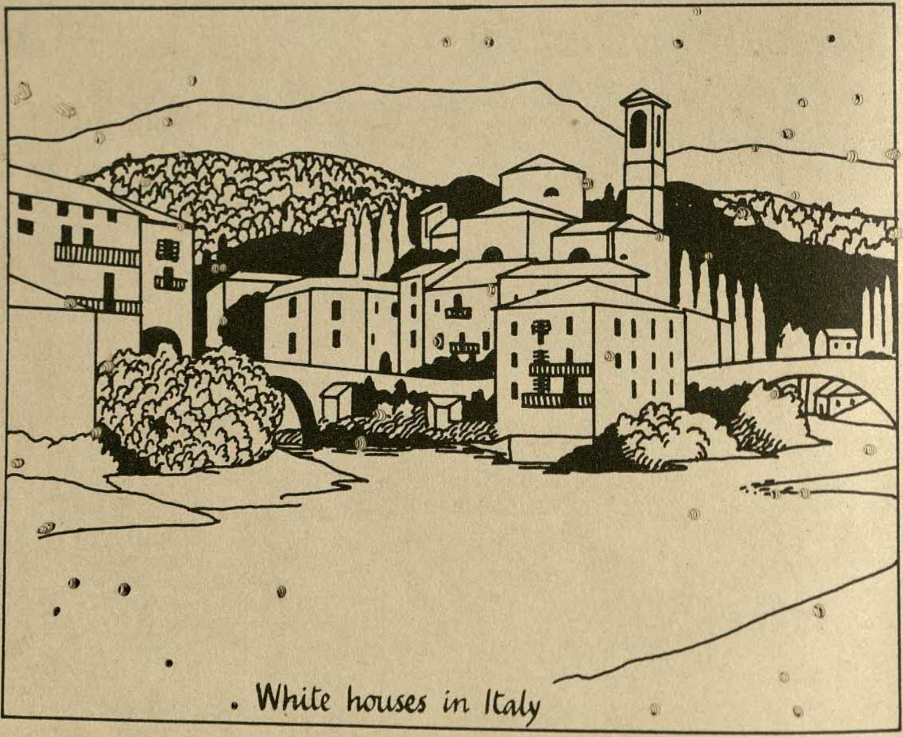

12
1
2
3
4
5
6
7
8
9
10
11

ONE of the ways in which heat is lost from a hot object is by radiation. The speed with which heat is lost depends on the surface of the object. If it is a dull black then it loses heat by radiation faster than if it is white and shiny.

Do you know what the word "absorb" means? In what connection is the word often used?

In the same way that a dull black surface is a better radiator of heat than a white shiny one, so a dull black surface absorbs heat better than a white shiny one. In fact we can say that surfaces that radiate heat well absorb heat well, while those that radiate heat badly, absorb heat badly. Remembering this see if you can answer the following questions. You can if you like, write out the questions and answers in your record books, with little sketches to illustrate your answers.

1. Why are the houses in some countries painted white? In which parts of the world would you expect to see such houses?



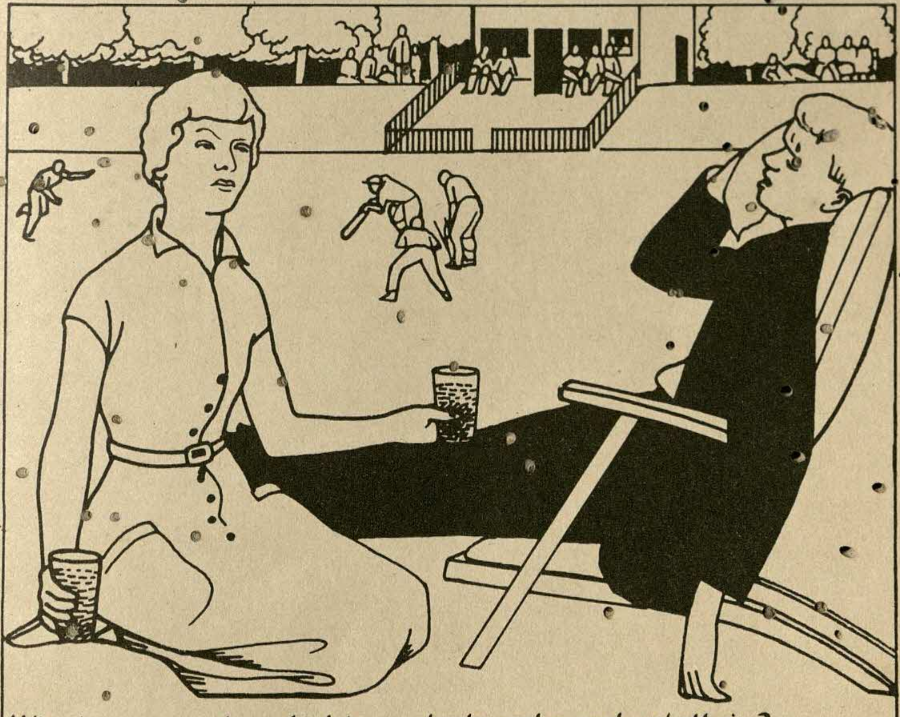
White houses in Italy

—OR WHITE CLOTHES IN SUMMER?

2. Why should the outside of metal teapots and kettles be kept bright and shiny?
3. In which are you most likely to feel cooler in summer, light coloured clothes, or dark coloured clothes?

Heat that is radiated from the sun, or from a fire, passes through the air without hardly warming it. Some of the heat from the sun is absorbed by dust and clouds, but if the air is dry and free from dust, very little heat is lost by this means. Can you explain why on a clear winter's day, although the sun may feel quite warm, the snow on the ground barely melts?

Is your classroom heated by hot-water "radiators"? The name is misleading for most of the heat from a hot-water radiator is obtained by convection currents. So the size of the "radiator" is more important than its colour. Why should the surface area be large? On the other hand electric fires (or radiators) depend largely on radiation.

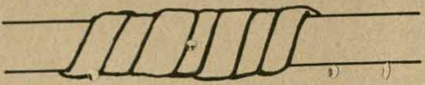


Which are cooler light or dark coloured clothes?

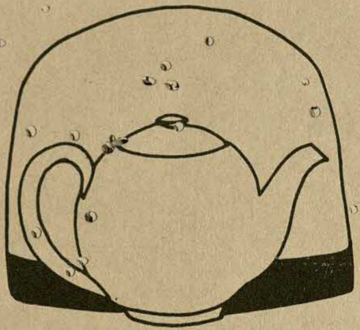
GOOD CONDUCTORS—

THERE are many household objects, especially in the kitchen that are made of metals. We have seen that metals are good conductors of heat. For example, frying pans are made of metal and because of this heat from the hot-plate, or flame, is quickly conducted to whatever we are cooking. At the same time heat would be quickly conducted to the handle if it was of metal. To protect the hand from being burnt, the handle of the pan must be insulated. What materials are good insulators?

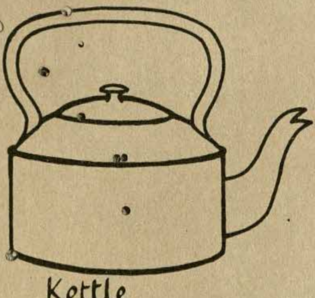
Here we have several simple things that you will probably find in your homes. There are as well several things that can be found in Nature. (*Remember that insulators can keep out cold, just as they can keep out the heat.*) Make copies of these in your record book. Perhaps



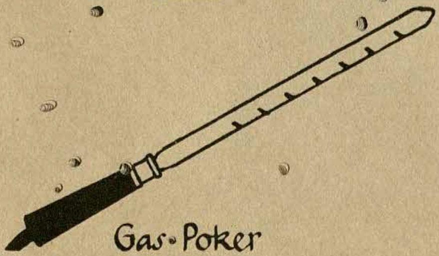
Felt lagging to insulate cold water pipe. This stops freezing in winter. Lagging also prevents heat from being lost from hot water pipes.



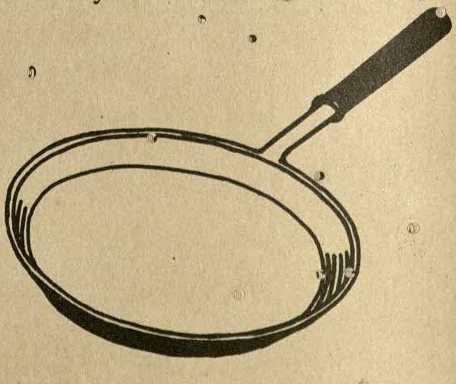
Teapot and cosy



Kettle



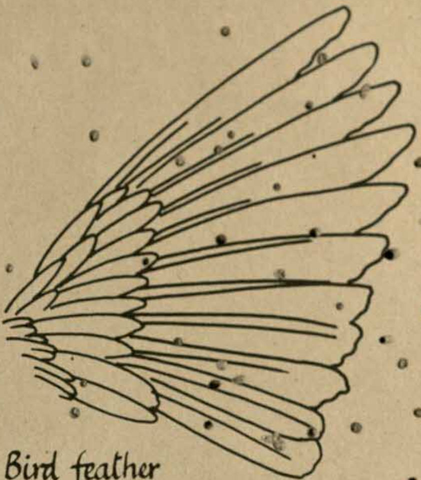
Gas-Poker



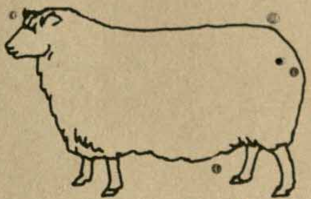
Frying Pan

you can think of some others that are not shown here. Underneath each drawing make a note of the material it is made from, and why it is so useful in each particular case. One of the drawings has been completed in this way for you, as an example, but you may be able to think of another way that you like better; if so do it your way.

Here is another experiment for you to do. Use the two cans that you used for your experiment in radiation. This time wrap one of the cans in felt, or cotton-wool, or some such insulator. The other can is left uncovered. Fill both with hot water. After stirring read the temperature of the water in both cans, every few minutes. Make a graph of your readings, as you did for the other experiment. What can you say about this graph?

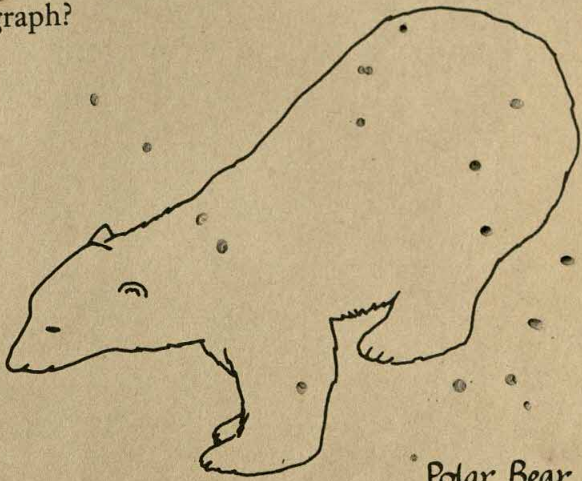


Bird feather



Sheep

Eskimo



Polar Bear

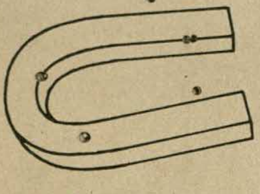
A CROSSWORD PUZZLE FOR YOU

Across

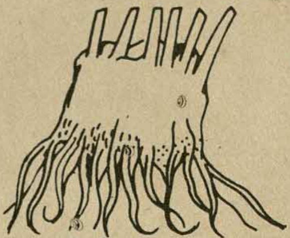
1. Inert gas.
4. William Gilbert experimented with one of these.
8. Always.
9. Male person.
10. Divide to increase.
12. Short for morning.
13. Short for meteorological.
14. Mid-day.
17. Type of gun.
19. An athlete does.
21. Twenty hundredweight.
22. Gives out heat.
23. To colour.
25. The sun does this.
27. It burns.
29. Opposed to.
31. Watchful.
33. Iron is more than water.
34. Opposite of compress.

Down

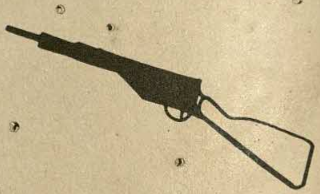
1. Mixture of gases.
2. Pointer on sundial.
3. Home for baby birds.
4. To find the size.
5. Limb.
6. Inert gas.
7. Short for Theobold.
11. Number.
15. Found in the air.
16. Negative.
17. Water as a gas.
18. Preposition.
19. Hot air does.
20. For catching fishes.
24. We hear with these.
26. Sorrowful.
28. Part of a plant.
30. Our eyes do this.
32. Underside of a hill.



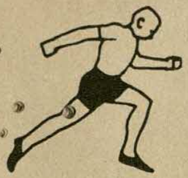
4 Across



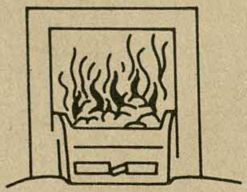
10 Across



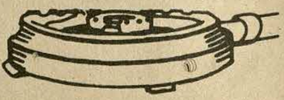
17 Across



19 Across



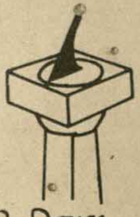
22 Across



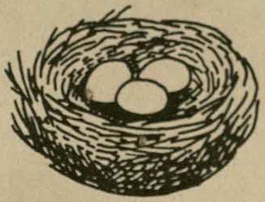
27 Across

A CROSSWORD PUZZLE FOR YOU

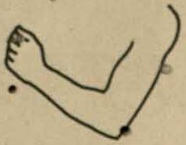
1	R	2 G	O	3 N	■	4 M	5 A	G	6 N	E	7 T	■
	■	N	■	8 E	V	E	R	■	E	■	9 H	E
10	O	O	11 T	S	■	12 A	M	■	O	■	E	■
■	■	13 M	E	T	■	S	■	■	14 N	15 U	O	16 N
17	18 T	A	N	■	19 R	U	20 N	S	■	X	■	O
21	O	N	■	22 F	I	R	E	■	23 D	Y	24 E	■
	■	■	■	■	25 S	E	T	26 S	■	27 G	A	28 S
29				30 S	E	■	■	31 A	32	E	R	E
	■	■	■	E	■	■	■	33 D	E	N	S	E
■	34 E	X	T	E	N	D	■	■		■	■	



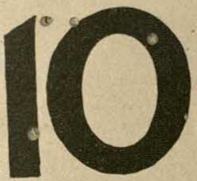
2 Down



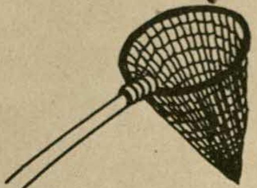
3 Down



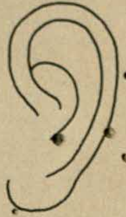
5 Down



11 Down

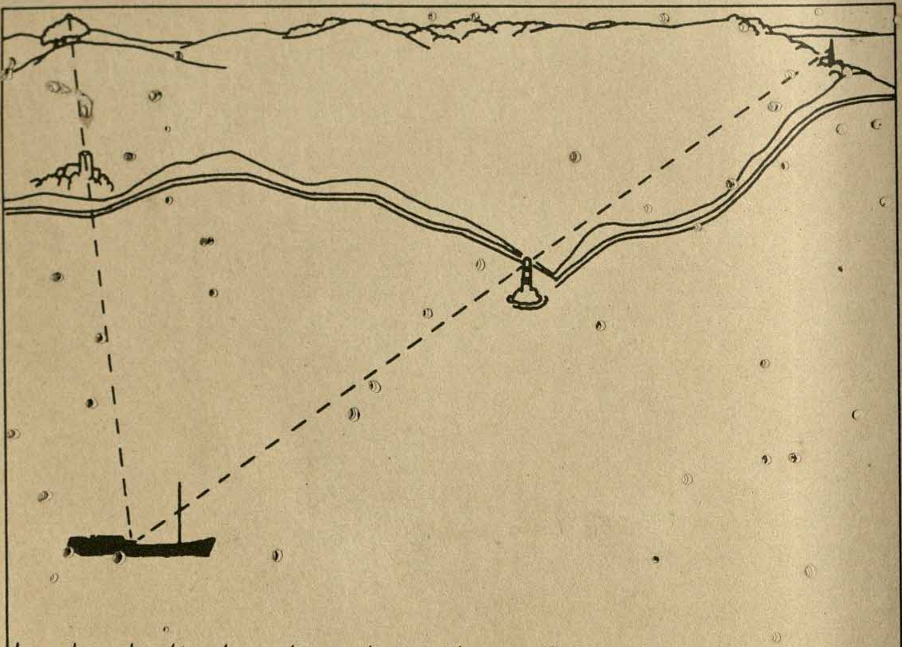


20 Down



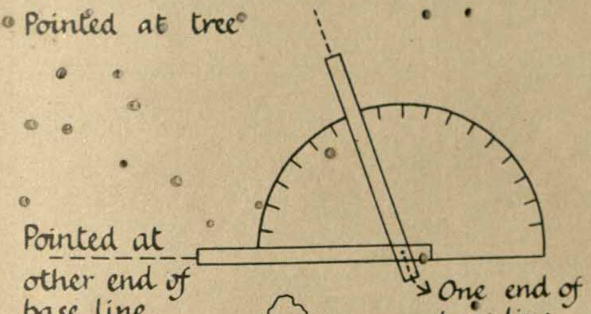
24 Down

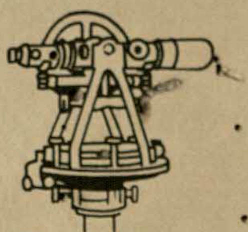
HAVE you ever had the luck, when on holiday at the sea, to go out with a fisherman? Some of the fishermen put down lobster pots. These are left, and picked up later on. Has it ever occurred to you that the fishermen know just where to find their pots? After all, there are no means of marking the spot out at sea, although most pots are put down off the coast, and usually in sight of land. The fishermen make use of "landmarks". Probably they can see a lighthouse or a building such as a church spire, or maybe just a clump of trees on a hill. They make a mental note of their position in relation to such landmarks. For example, they may find that when they are in position, a straight line passes through a clump of trees on a hill-top, through a lighthouse and through their own position at sea. Of course this does not "fix" the position. A second line must be found passing through where they are and two other objects. Once these objects have been found, the fishermen will always be able to return to the spot. You can see this in the picture. They can only do this because light travels in straight lines.

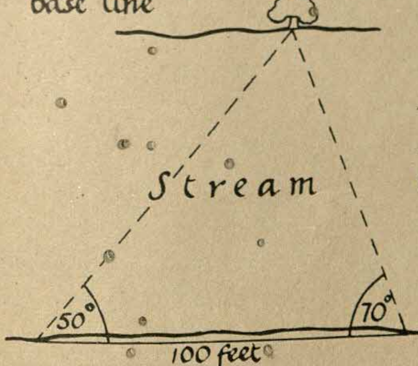


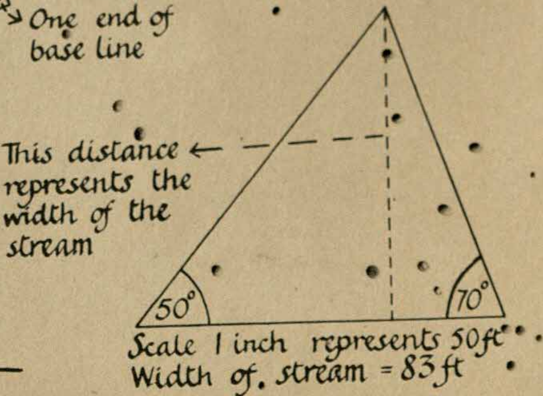
Landmarks lined up to mark position of Fishing boat out at sea

We make use of the fact that light travels in straight lines to find out how far away something is, without actually going there. The example we will take is to find how wide a river is, without crossing over it. Along the bank of the river, a distance, say 100 feet, is measured in a straight line, opposite something such as a tree on the other bank. To measure accurately the angles shown an instrument called a theodolite may be used. But we can do this another way, using an instrument like a large protractor with two arms. The two arms on the protractor are sighted, one on the end of the straight line on the bank, and the other on the object on the other bank across the river. This is repeated at the other end of our straight line. The angles so formed can be read off from the scale. Now a scale drawing is made and from this the width of the river can be measured. This is much easier to follow if you do it for yourself. Mark out an imaginary river in your playground and using a protractor like the one shown, find the width of your "river". Then check your answer.




Theodolite

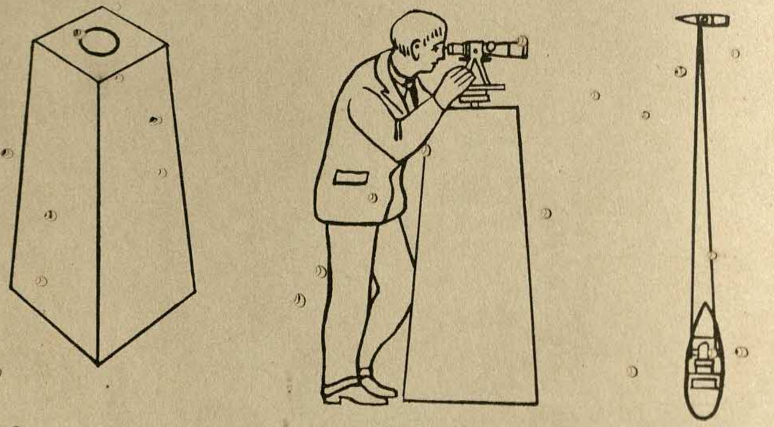



This distance represents the width of the stream
50°
70°
Scale 1 inch represents 50ft
Width of stream = 83ft

IN the same way that we can find the width of a river without crossing over, so we can find the distance to far objects without going to them. Of course if we can visit the distant objects too, and look back, we can check our answer. If we go to each of the three points of the triangle in turn, and from each point measure the angle made by the other two, we will be doing what surveyors do, "triangulating" as it is sometimes called. The whole of the British Isles have been covered in this way, and by this means the distances between any two points are accurately known, and from this accurate maps are made. In this case, however, the distances between the points are often several miles.

Perhaps you have seen concrete pillars like the one in the picture. They have a metal piece in the top and are used by surveyors. They are called "trig points" and are often sited on the tops of hills. Can you guess why?

Have you ever wondered how battleships and other warships know how far away the enemy ships are when at sea? They use rangefinders. These make use of the same method as we used to find the width of a river. The instrument itself acts as the two points on the bank of the



A Trig Point

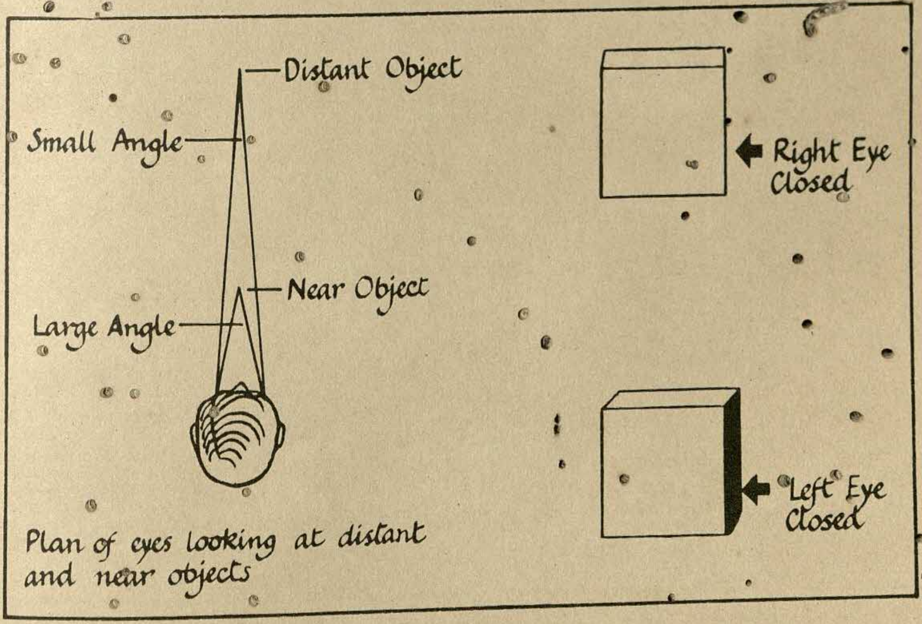
Surveyor using Trig Point

Boat using Range Finder

river with the enemy ship as the point on the other side. Instead of having to measure the angles, and then either drawing a scale diagram, or working out the distance, many of these instruments give the distance straight away.

Our own eyes act as rangefinders for us, and by experience we know how far away an object is that we are looking at. You may have noticed that if you look at something quite near you with the right eye, at the same time covering up the left one, the object does not appear the same as it does when you look at it with the left eye, with the right one covered. Try this with a small box held about a foot away from your eyes.

The nearer to the eyes the object is, the greater will be the difference between that which the left eye sees, and that which the right eye sees. The farther away the thing is that we are looking at, the less becomes the difference between what the two eyes see. Although the two eyes see different pictures, they are made up into one picture by the brain. Another effect of looking with two eyes at something, is that we get a feeling of depth. We do not get this when looking at the same thing with only one eye.



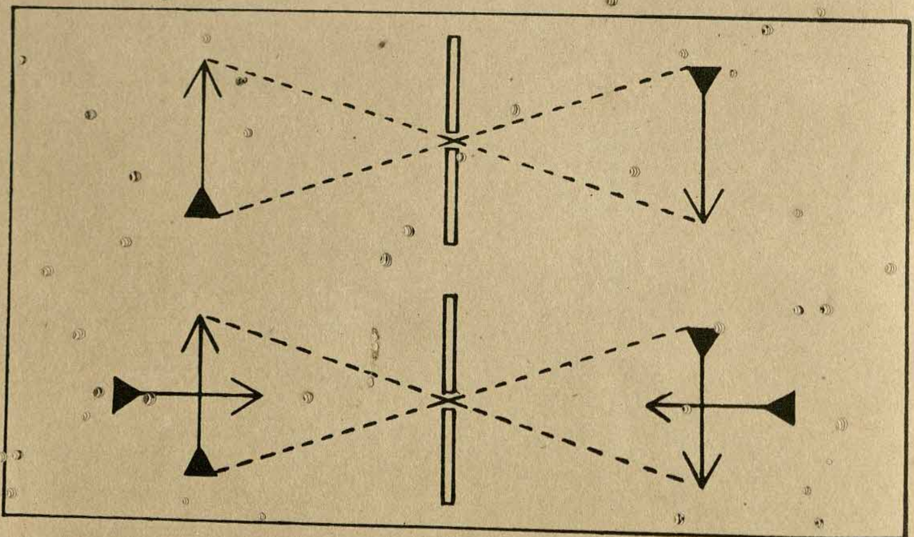
Plan of eyes looking at distant and near objects

THE UPSIDE-DOWN CANDLE

HERE is an experiment for you to do. It must be done in a darkened room. You will need two pieces of cardboard. Make a pin-hole in the centre of one piece. Prop this upright on a bench or table. In front of this stand a lighted candle. On the other side of your upright card with the pin-hole in it, hold your second card. This card we will call the screen. Now by moving the candle and the screen about, get a clear image of the candle flame on your screen. Is the image of the flame the right way up, or upside down? An upside down image is sometimes said to be inverted. What happens to the image if the screen is moved first of all farther away and then nearer? Does the brightness alter in any way?

Although this experiment is not very accurate, if it is done carefully you will get some quite good results. Now try making the hole in your card a little bigger. What happens now to your image of the flame?

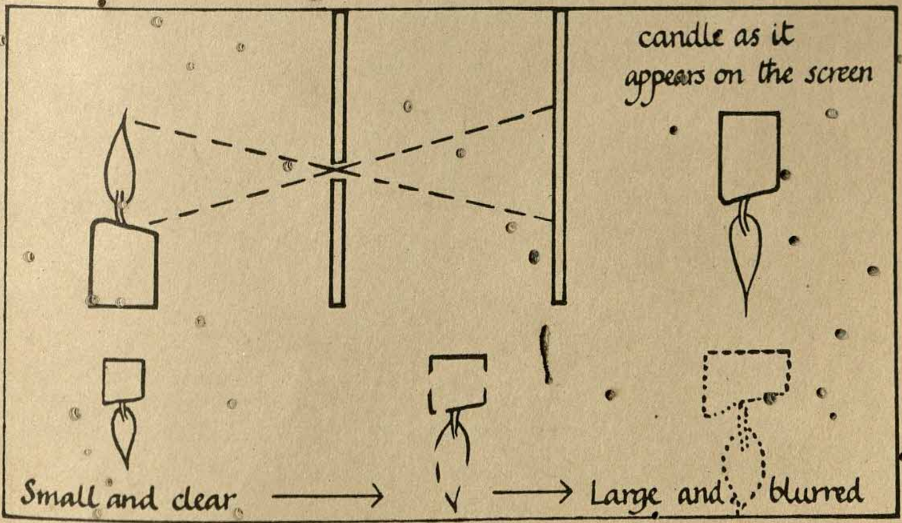
If you have done this experiment properly you will see that the image is upside down, or inverted. Can we explain how this happens? Perhaps the diagram here will help you. We have said that light travels in straight lines. Let us suppose that instead of a candle flame we are using a very brightly lit arrow. A tiny ray of light travels from the tip of the arrow in a straight line until it hits the screen. It gives



a tiny spot here. In the same way a ray of light will travel from the tail of the arrow until it too hits the screen giving a tiny white spot. Imagine this happening for every part of the arrow and you will have an image of the arrow formed on the screen. It will be upside down.

Suppose that instead of using a single arrow that is brightly lit we used two such arrows, crossing each other at right angles. The image thrown on to the screen would look like that shown in the diagram. Copy this into your record books but draw in the lines that the rays of light take, thus showing how the image is formed on the screen. You will see that the image is upside down and left to right.

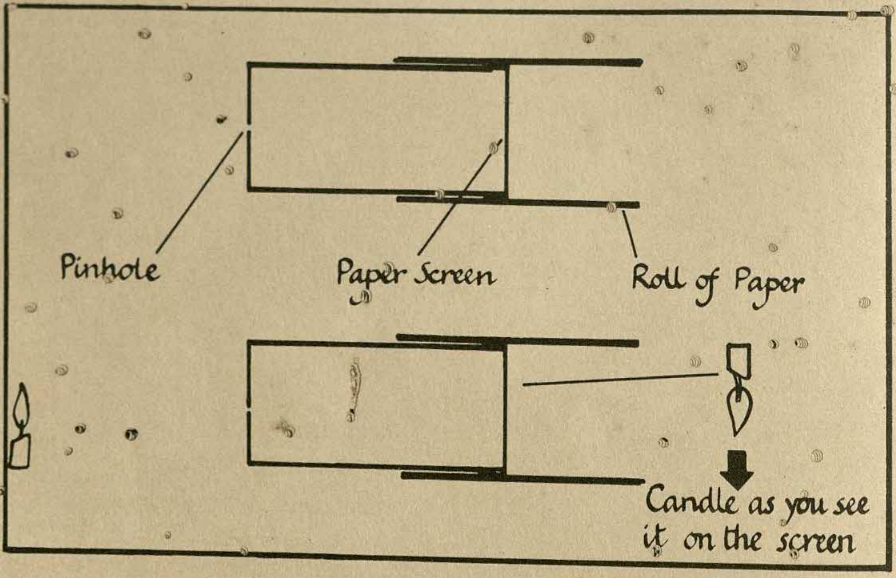
Next time we are going to make a pin-hole camera, and for this we will need one or two simple things. You can probably find them at home. You will need to bring a clean empty tin, such as has been used to hold vegetables or fruit, some sticky paper, and a piece of greaseproof paper large enough to cover the end of the tin, with a little spare to overlap, and a newspaper or some brown paper large enough to form a hollow tube around the tin, and at least twice as long as the tin. Probably you would like to work in twos so arrange between yourselves which of the above things each of you will bring.



YOUR PIN-HOLE CAMERA

HAVE you brought along all the things that you were asked for last time? As well as these you will also want a needle. The first thing you must do is to make a fine hole in the end of your tin with the point of the needle. Either twist it in, holding the needle in a pair of pliers, or tap it very gently, because you must not have a hole that is too big. Gently turn the needle about in the hole so that the edges are clean. The other end of your tin is the open end, and over this put your greaseproof paper turning the overlap round the sides of the tin and when the end is smoothly covered secure the paper in position with your sticky paper. This end is your screen and on this you will see the images. So far so good, your camera will work quite well like this, but it will be even better if you roll your newspaper, or brown sheet of paper round the tin so that it extends beyond the greaseproof paper at the end, and forms a tube.

You must not expect to get images of everything that you look at through your camera. The brightness of the object you are looking at is very important. If it is a bright and sunny day and you look through your camera at the windows you ought to get a good image of them on your screen. But on a dull day, or in a darkened room, you must look at something bright, like a candle or an electric light bulb. You will

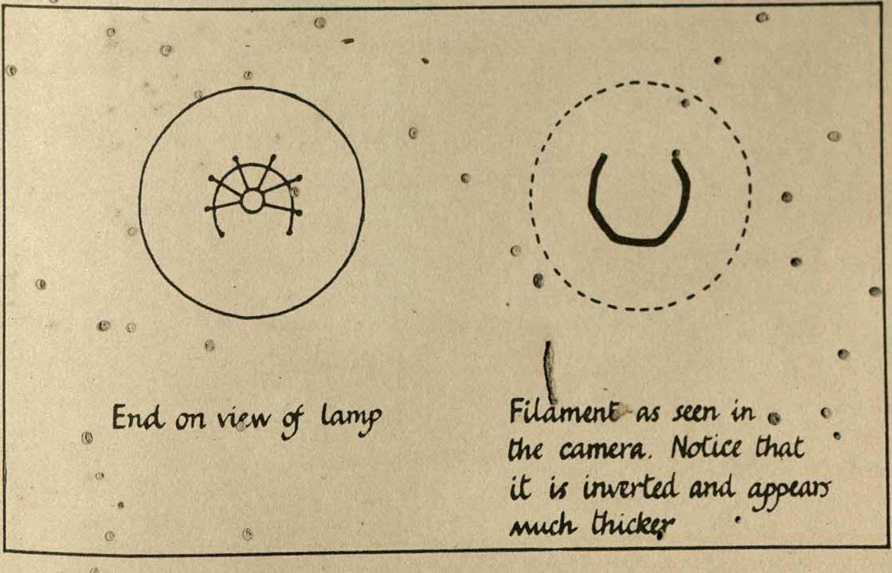


get a very good image of the candle when the camera is only a few inches away from it. Is the image upside down and reversed, left to right like the crossed arrows you drew? With the electric light bulb you will see the filament of the lamp.

When you have tried all this, you can then begin to alter one or two things, and see what happens. Try moving the pin-hole nearer to the candle flame; does the image get bigger, or smaller? How does the brightness alter? Can you explain why these changes should make a difference? Now alter the size of the pin-hole. Make it a little larger with a thin nail or gimlet. Now look again at your flame, or bulb. What has happened?

Perhaps you would like to experiment with your pin-hole camera when you get home, but do be careful and get permission first. At night when it is quite dark put a lighted candle on the table and see just how clearly you can get an image of it on your screen. Maybe it would be a good idea to get Father or Mother to help you with this experiment.

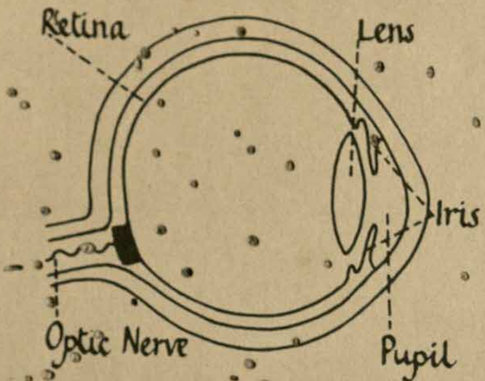
A camera works on the same principle, although there are many refinements. The lens gives a more clearly defined image which can be permanently recorded, while allowances can be made for distances and brightness.

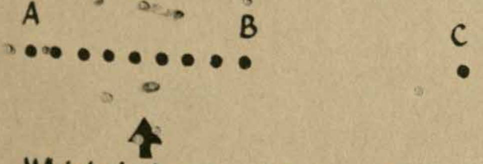


End on view of lamp

Filament as seen in the camera. Notice that it is inverted and appears much thicker

YOU SEE WITH YOUR EYES—



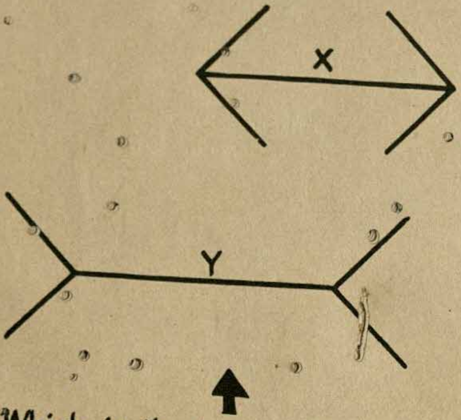


Which is longer A to B or B to C?

TASTE, smell, sight, hearing, and touch. These are the five senses. Most of us have them all and we take them so much for granted. But have you ever considered which of these you would prefer not to lose? Naturally no one wishes to be without any of them, but some people are without one or more of them. Perhaps those at the greatest disadvantage are those who either lose, or have never had sight. So much of our life depends upon what we see. We use our eyes all day long, every day of the year. We see! But how, and why?

The human eye which allows us to see is automatic in its working. Let us take an example. Suppose that you are looking at a bed of flowers in the garden. How do you see them? Light from the flowers enters the eye through the lens. An image is formed on a screen at the back of the eye. This screen is called the "retina". We will be reading more about the iris and lens of the eye later on. Very simply the eye works in the same way as your pin-hole camera.

In the retina, or screen at the back of the eye, are a great number of nerve endings. The other ends of these nerves go to the brain. Each tiny nerve tells the brain the



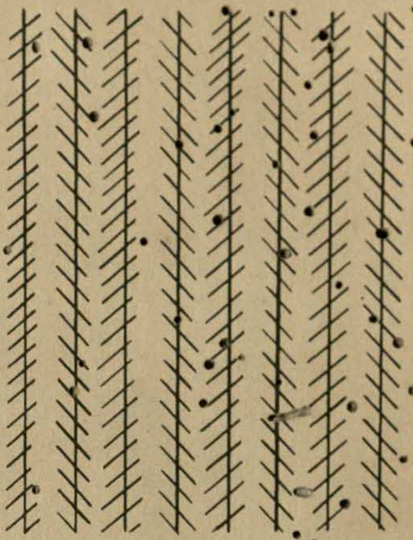
Which is the longer line X or Y?

type of light ray that has fallen on it. The brain collects the information and makes up a complete picture. This is the picture that we "see".

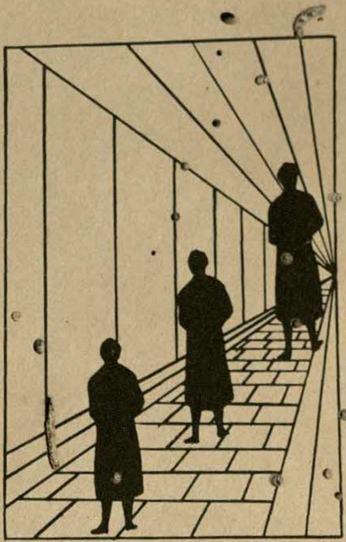
In your pin-hole camera you will remember that all your images were upside down, and reversed left and right, like the crossed arrows you drew in your record books. Because light travels in straight lines the things we look at reach the retina in the same way. But the brain does one more important thing for us, it not only collects all the information, or messages through the nerves, but when the picture is complete it turns it the right way about for us.

In spite of the fact that most people's eyes look much the same, there are those who can see very much more than others. Perhaps you have heard or read about the native trackers who can read a trail on the ground and surroundings, a trail that many white men could not even see, not even when it is pointed out to them.

Although our eyes are very wonderful, they often play us tricks. Look at the various pictures and see if you can get the right answers. The fact that the eye can be deceived is put to good use both by us and by animals.

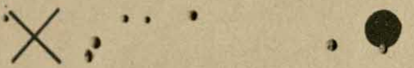


Are these vertical lines parallel?

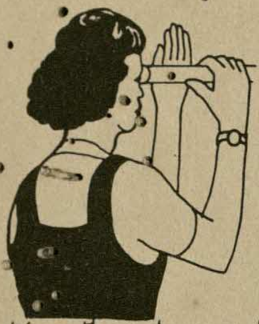


Which of these figures is tallest?

OUR EYES DECEIVE US

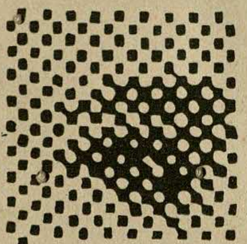


The Blind Spot



Looking through your hand

Newspaper Photograph

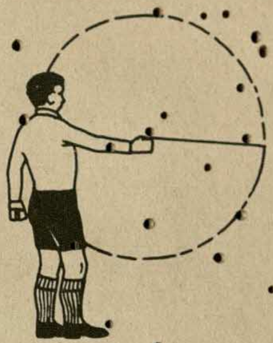


Enlargement of Newspaper Photo

HAVE you ever heard of the "blind spot"? Do you know what it means? You can find out what it is quite easily. Hold this book up in front of you and close one of your eyes. Now, with the other eye look at the cross. Can you see the black spot as well? Slowly bring the book nearer to you, looking at the cross all the time. When the book is in a certain position, the black spot will suddenly disappear. Continue moving the book towards you and the black spot will come again. Keep on looking at the cross all the time. There is one spot on the retina, or screen of the eye, where the nerve enters the eye. This nerve is called the optic nerve, and when the image of the black spot falls on the optic nerve the spot cannot be seen. It is this entry of the optic nerve that causes the blind spot.

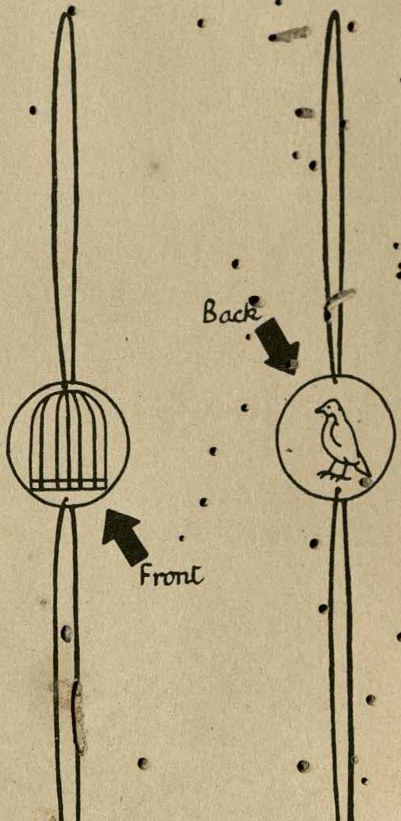
Can you look through your hand? If you have never done it try now. Simply roll a piece of paper into a tube, hold it to your right eye so that you can see through it. Keep your left eye open. Hold up your left hand against the side, and about half-way down, the tube of paper. What do you see?

Next time you look at a newspaper, have a special look at one of the pictures. When you glance casually you see a picture. But if you look into the picture, especially if you look with a magnifying glass, you will find that it is a series of tiny black dots in a particular pattern, and not a picture as you saw at first glance.

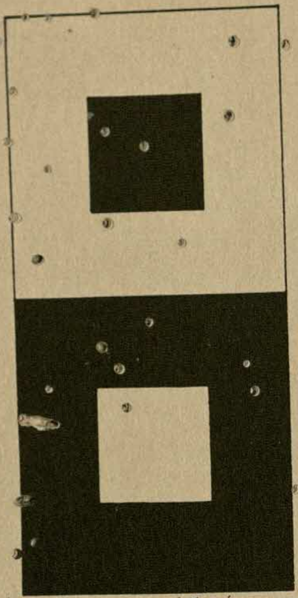


If a piece of string is smouldering at one end, and you whirl it round and round, your eyes will tell you that it is a continuous ring of fire. But you know that this is not so. When the glowing end of the string is in one position, you see it there. The string moves on, but for a while your eyes still see the glowing end in its original position. This is called "persistence of vision". Another example of this is when you look directly at an unshaded lamp and then close your eyes. You go on seeing the glow of light.

Here is something else for you to do. Cut out a cardboard disc of two inches in diameter. Make two small holes as shown, and through each thread a length of string some ten inches long. Tie it into a loop. On one side draw a bird on a perch, and on the other side a cage. Twist the loops and pull them with your hands. This causes the cardboard disc to rotate rapidly. What do you see? This is another example of persistence of vision. Another most interesting example of this persistence of vision is the cinema film; we shall deal with this later.



INSTITUTE OF EDUCATION FOR WOMEN ★ CALCUTTA-27



Which is the larger of the inner squares?

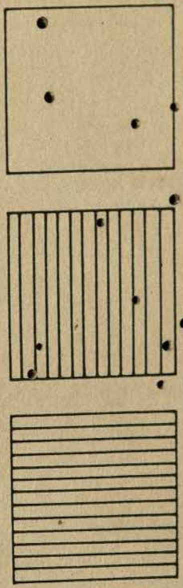
SOMETIMES optical illusions are used purposely to make something seem to be what it is not. Look at the black square in its white surround, and then at the white square in its black surround next to it. One of them appears to be bigger, which is it? Now measure the two squares, and you will see that they are actually the same size.

Another example of this is the filament inside an electric lamp. When it is alight it is easily seen and appears quite thick. Yet when the lamp is cold you can see just how fine the wire really is. This

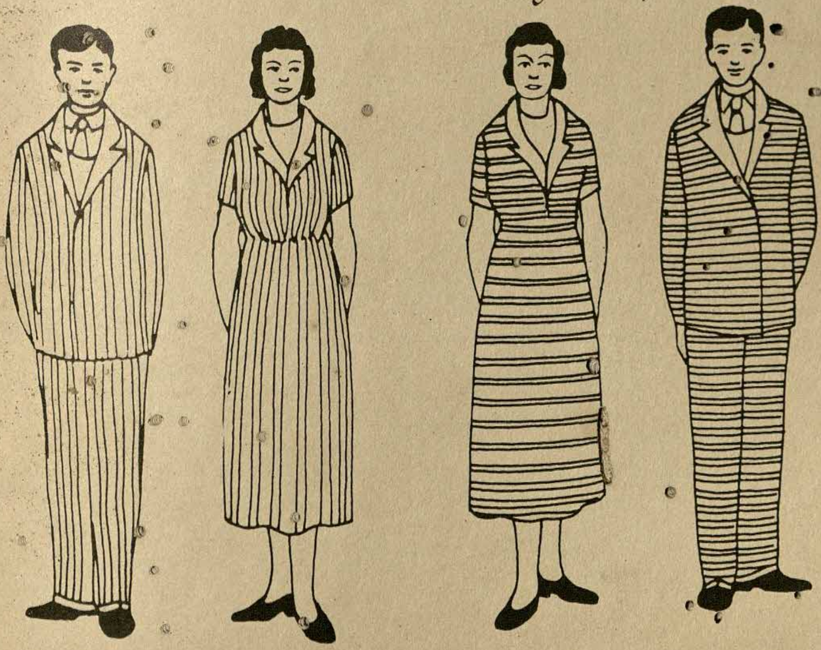
same effect can be obtained in our clothing.

A person dressed in light coloured clothing in the midst of others dressed in dark colours will appear "larger than life", and the opposite is seen with a person wearing dark clothes among others wearing light colours.

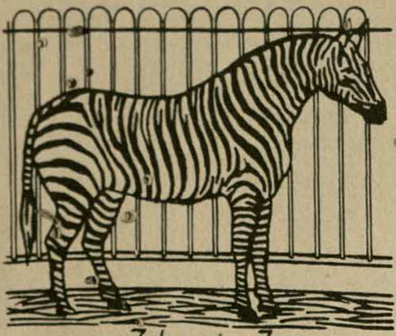
It is a well-known fact that lines or stripes can be used to alter a person's appearance; vertical lines can give one the appearance of height, and horizontal lines can give an illusion of width. See if you can find examples of this in magazines.



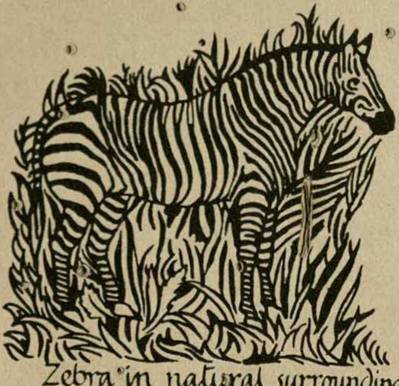
Which of these squares is the wider?



Snake in tree is difficult to see



Zebra in Zoo



Zebra in natural surroundings

HAVE you ever been to a zoo? There are many kinds of wild animals to be seen there, and they are of all shapes and sizes. Their colouring too varies quite a lot. There are black bears and white bears, sandy coloured lions, and the two-coloured zebras and giraffes. There is also a small animal which can change its colouring, it is called a chameleon.

Why do you think these wild animals have these colour markings?

Seen in zoos, these animals nearly always stand out against their backgrounds, but have you ever thought about them in their natural surroundings? Maybe you have seen pictures of them in these conditions. Actually in their own home countries they would probably be very difficult to spot at a distance, because they merge into their background. The particular colouring of the animal protects it from being seen easily, and we call this "protective colouring". There are some animals that change their colour to suit the season. The Arctic fox is one of these, it is white in winter but brownish in summer. Can you think of any other examples?

We can recognise objects by their outline. If that outline can be broken up, then it is very much more difficult to recognise the object. You would probably imagine that it is easy to spot a zebra, but in its natural surroundings and at a distance its very markings break up its shape, and so it becomes harder to see.

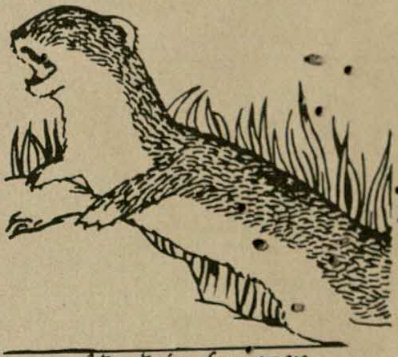
There are some varieties of the humble moth that are sometimes very difficult to see. For example when they are on a wooden fence. Why is this?

Can you explain why some fish are a light colour on the underside and darker on the upperside?

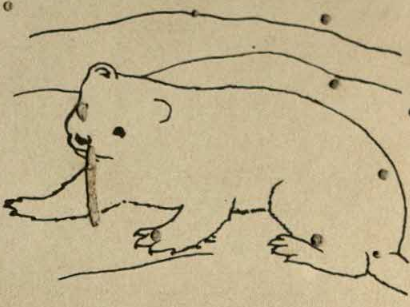
Many animals, birds, and fishes try to hide themselves from their natural enemies by colouring and shading. This colouring, or blending with the background, is another type of illusion and is known as "CAMOUFLAGE". But camouflage is not confined to the animal kingdom only, as many of you probably know. We ourselves make use of camouflage in wartime when we try to hide ourselves and our weapons from the enemy as we shall see later.

Make some coloured drawings or paintings of various animals first of all with no background and then a similar one against their natural surroundings, so that your pictures show how colours and patterns make them more difficult to see.

Pheasant on nest



Stoat in Summer



Northern Stoat in Winter

USING CAMOUFLAGE—

NATURE has provided animals, birds and fishes with two means so that they can avoid being seen by their natural enemies. One way is by protective colouring, and the other by breaking up their outline.

In wartime we have borrowed this idea of camouflage from Nature and used it to hide men and their weapons.

Have you ever seen something on the ground glinting in the sun, and thought that it must be something of great value, only to find that it is just a piece of broken glass, advertising its presence and position in the bright light? If the surface of the glass had been dull it would not have caught the light and in all probability you would never have seen it.

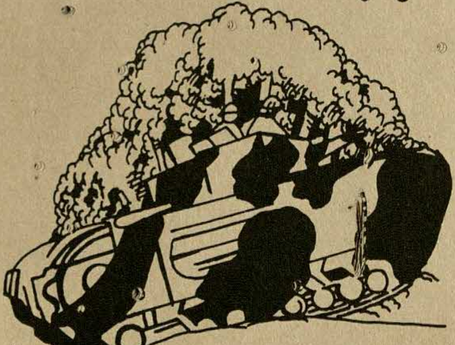
That is the problem that had to be overcome during wartime. Anything that was shiny had to be covered by a coating of dull matt paint. White men's faces, being pale in colour, shine at night in the darkness, but obviously they could not cover their faces with a dull

No Camouflage

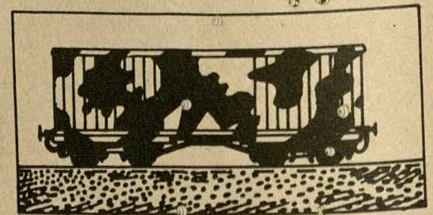
No Camouflage

Good Camouflage

Good Camouflage



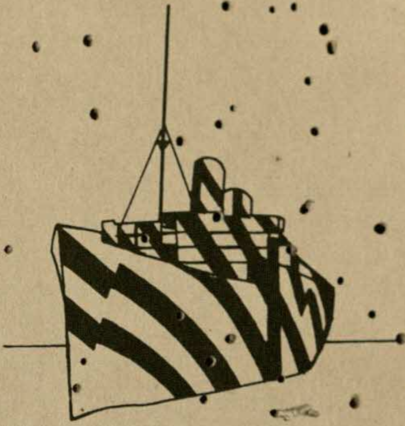
Camouflaged vehicles



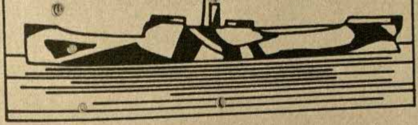
matt paint. Do you know what troops do before going out on night operations to avoid being seen?

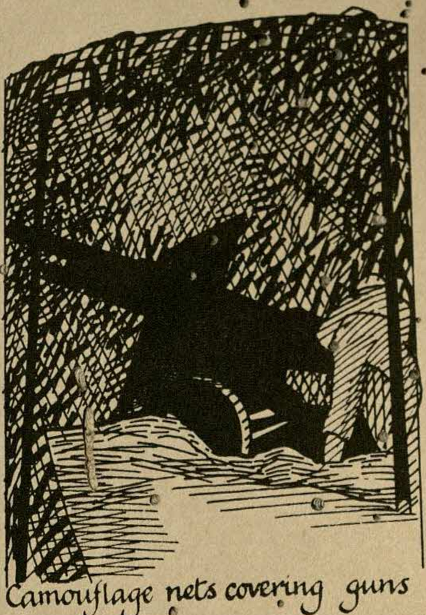
We have said that animals can be recognised by their shapes and so can army transport, or ships at sea. In wartime we camouflage transport and warships by breaking up their outline with bands of paint over the initial covering which dulls the surfaces. We do what Nature does for the zebra, break up the outlines. This painting also makes it more difficult to tell which way a ship is moving. Remember it may be seen only against a background of sea and sky, and the observer will probably be moving as well.

Apart from being seen from the ground, such things as guns and vehicles may be seen from the air. Their positions can be made more difficult to see if they are painted to match their surroundings, but there is something else that has to be guarded against. Shadows! Shadows can be hidden by covering the objects with large nets, and this prevents their positions being given away when they are looked at from the air.



Ship Dazzle Painted





Camouflage nets covering guns

GALVANI AND VOLTA—

AT the end of the eighteenth century an Italian named Galvani, together with some students, was experimenting with frogs. He noticed that if two different metals were touching a dead frog which was damp, the muscles of the frog twitched. Two different metals such as copper and iron, or steel, gave this effect, but if two pieces of the same metal are used this effect was not seen.

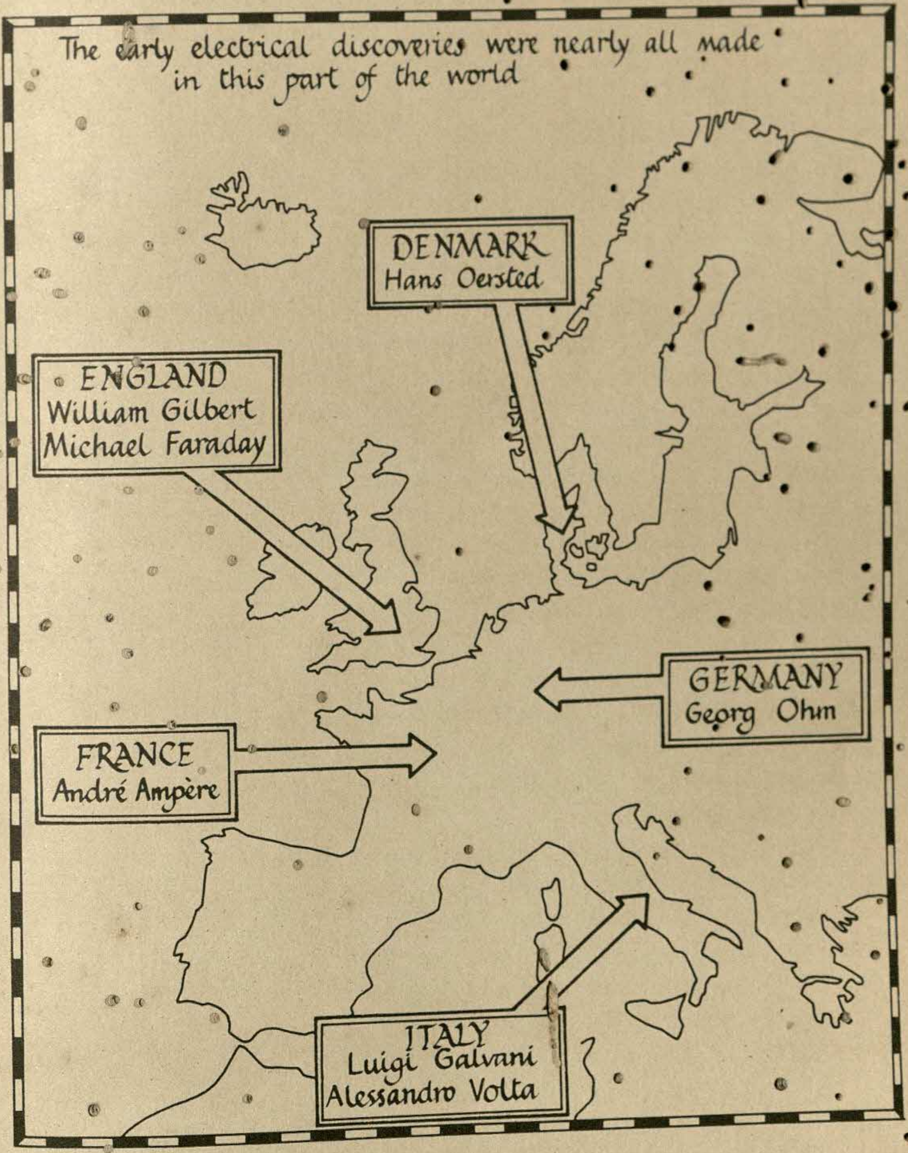
Galvani tried to explain this. He thought there was a kind of "animal electricity" and that it was strong in the muscles. He did not think that the metals had anything to do with the effect he had seen.

A fellow countryman, Volta by name, did not agree with Galvani's explanation, and suggested that the important point was the metals used. He also suggested that the frog's muscles were only important in so far as they provided a path for the electricity between the two metals. Volta then showed that when two metals such as copper and zinc are put on either side of a piece of cardboard that has been soaked in a solution of salt, electricity is produced. This showed Galvani's explanation to be wrong, because Volta had produced electricity without the use of an animal at all.

Volta continued his experiments. His next important step was to enlarge on the earlier experiment. He made an arrangement of copper, cardboard, zinc, cardboard, copper, cardboard, zinc, in that order. The metal he started with, copper, was different from the metal he finished with, zinc, and this time the cardboard was soaked in acid. When wires from each end of this arrangement were brought together a spark was produced. Volta had produced an electric current, and the supply was continuous.

From this experiment Volta went on to make another very important discovery. He found that an electric current could be made when two metals such as copper and zinc were put into acid without the cardboard separating them. But gradually the zinc dissolved away in the acid. This arrangement of metals in acid is called a "cell", and when two or more such cells are joined together a bigger electric current flows.

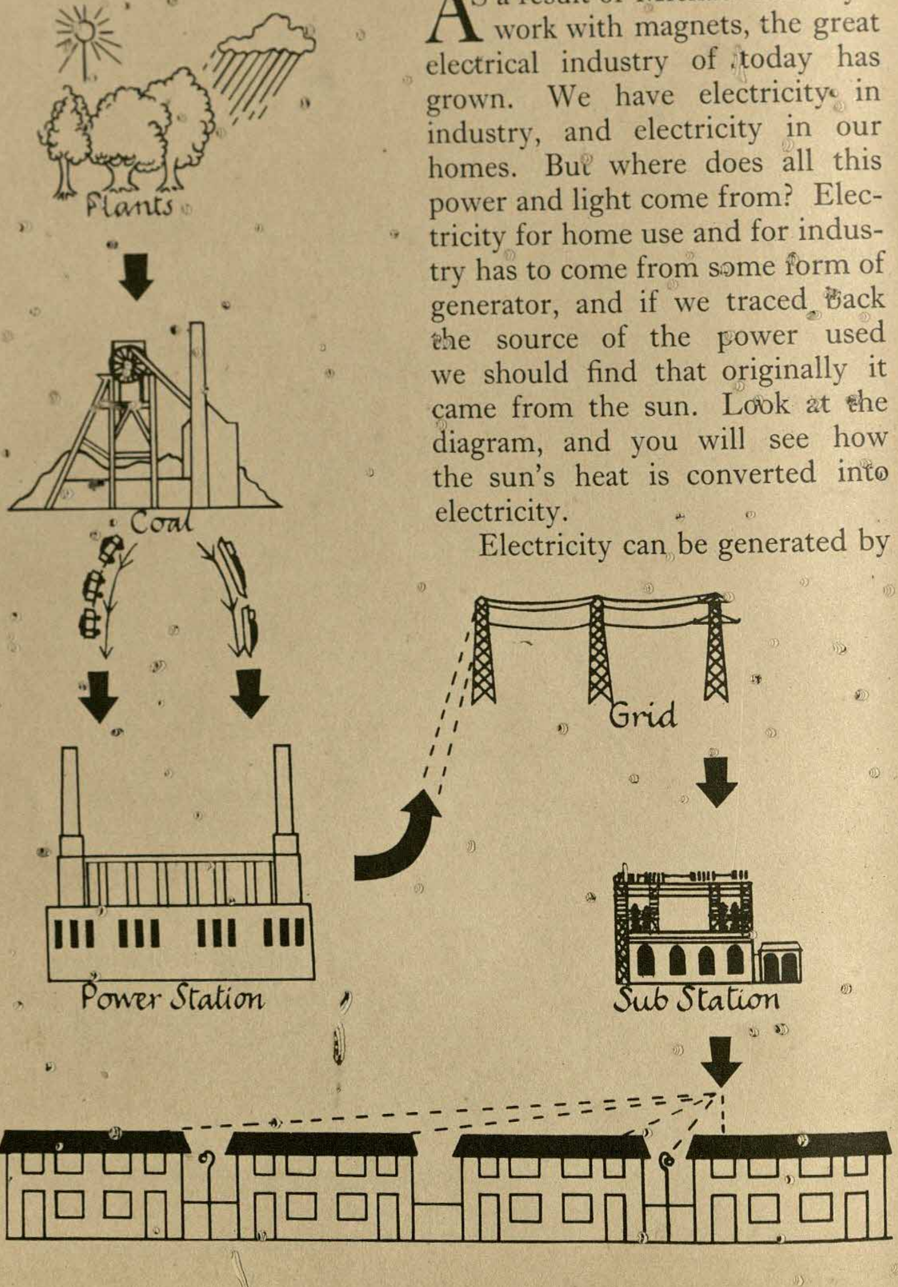
Next time you go to your local library look for information about the men whose names appear on the map. You will see that it is a map of Western Europe. Nearly all the early discoveries in electricity were made by men who lived in this part of the world.


The early electrical discoveries were nearly all made in this part of the world
DENMARK
Hans Oersted
ENGLAND
William Gilbert
Michael Faraday
GERMANY
Georg Ohm
FRANCE
André Ampère
ITALY
Luigi Galvani
Alessandro Volta

ELECTRICITY COMES ORIGINALLY FROM COAL

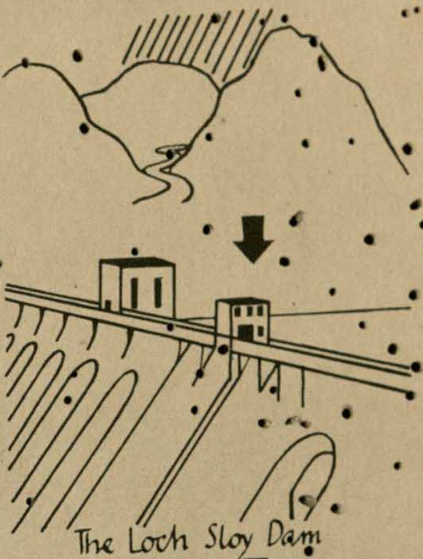
AS a result of Michael Faraday's work with magnets, the great electrical industry of today has grown. We have electricity in industry, and electricity in our homes. But where does all this power and light come from? Electricity for home use and for industry has to come from some form of generator, and if we traced back the source of the power used we should find that originally it came from the sun. Look at the diagram, and you will see how the sun's heat is converted into electricity.

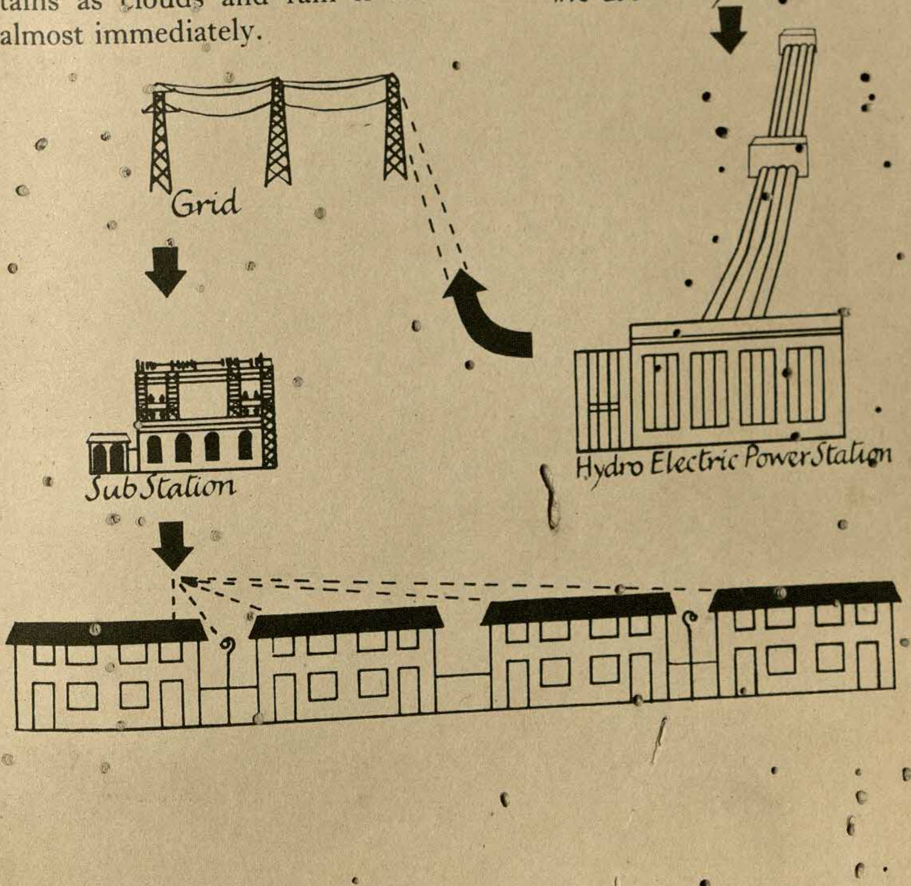
Electricity can be generated by



ELECTRICITY COMES FROM WATER POWER

water power. To do this large quantities of fast flowing water are needed. Some countries have this and can generate electricity fairly cheaply. Which countries in Europe can produce electricity by this means? Electricity produced by water power is called hydro-electric power. Try to find some pictures of electric power being made by this means and make tracings of them for your record books. In this case the heat of the sun is not stored. The water that is carried from the sea to the mountains as clouds and rain is used almost immediately.





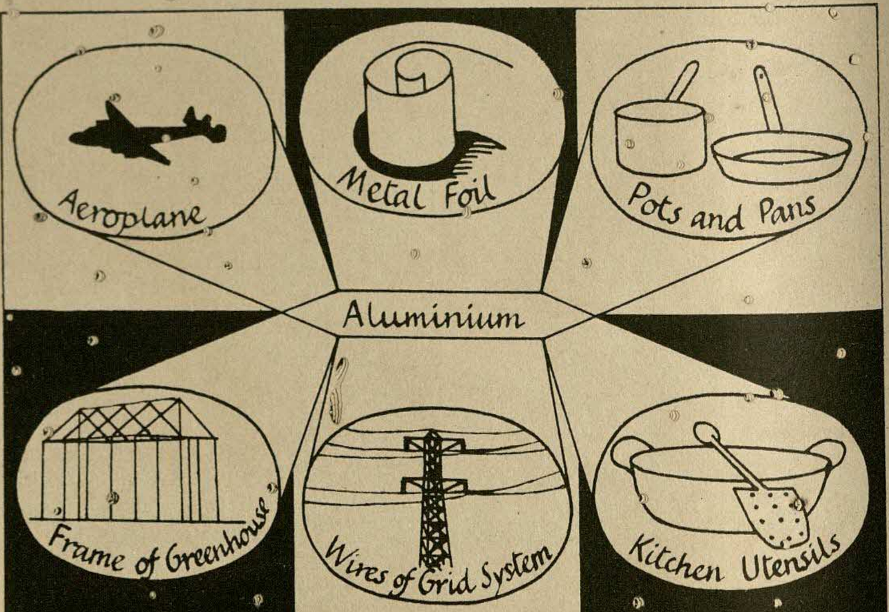
ALUMINIUM AND—

AT the end of the eighteenth century a way was found of making a continuous supply of electricity. The methods used were limited and only a small amount could be made at a time. This was of no use where a lot of electricity was wanted.

Last year we talked about Michael Faraday and how his discoveries helped to found the electrical industry of today. It was during the first half of the nineteenth century that he was busy with his experiments, and as a result of these a way was found to produce electricity on a large scale.

Gradually electricity became the form of lighting for many houses, and electric power was used in industry. A lot of new ways of using this power were found and developed. These advances began to affect everybody in their everyday life. We have seen how electricity has helped us in our kitchens, and we know the value of electricity for heating. But there are many other things that are made with the help of electricity in ways that are perhaps not so obvious.

Aluminium was a most expensive metal before electricity could be made on a large scale. It was not until 1885 that aluminium could be produced by using electric power. Where there is a "cheap" source of



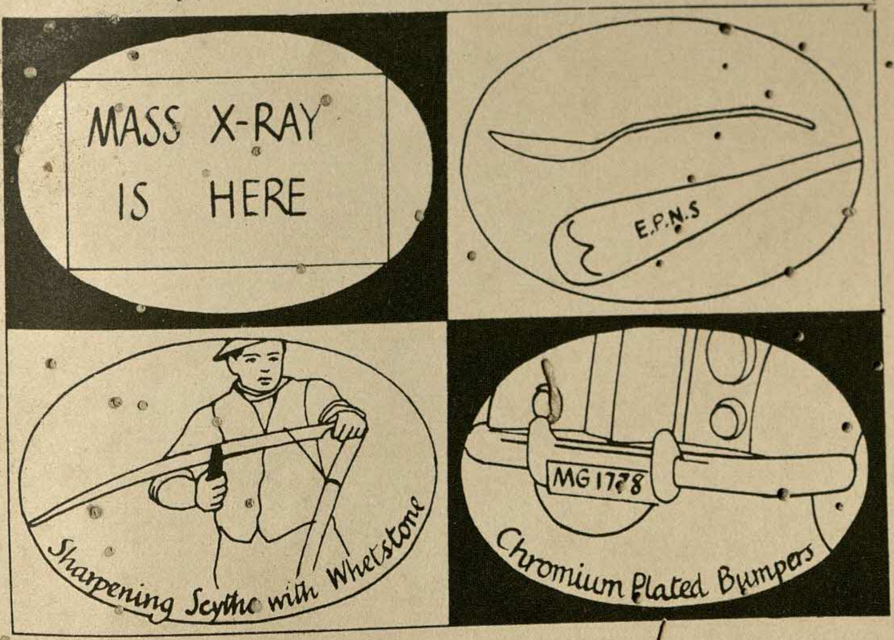
this power, for example when it is generated by water, then aluminium can be produced very cheaply. Today it is widely used; how many examples of its uses can you think of?

A very common metal, iron, and the steel that is made from it, suffers from the disadvantage of rusting when there is moisture present in the air. Today, one of the ways used to protect steel from rust is by plating it with another metal that is not affected by moisture and air. Sometimes a metal is plated with another metal to give a pleasing finish. In both cases the plating is put on by using electricity, and it is called electroplating.

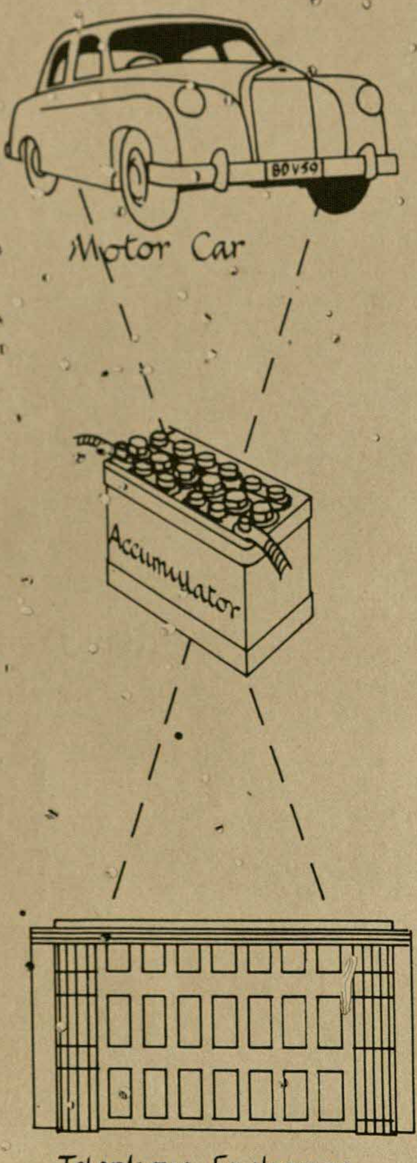
Copper that is used to carry an electric current should be as pure as possible. The impure copper is purified by using an electric current.

When electricity was used as power for electric furnaces a very high temperature could be reached. One of the things made in an electric furnace is carborundum. This is used for grinding wheels and is very hard.

Later discoveries brought about the X-ray, which is of great value in hospitals and in industry. Electricity plays an important part in all our lives today. What other examples are there?



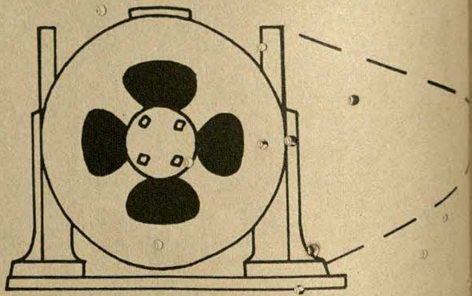
ACCUMULATORS—



WHEN a large quantity of electricity is required as on electric railways it must be supplied from a generator or a dynamo. Motor cars also need an electric current, and so do small hand torches and many other uses of electricity. Electricity from the mains supply is no good for these; the electricity has to be stored.

Electricity can be stored for future use by means of an accumulator. Accumulators can supply quite a large current, and they are used in motor cars, telephone exchanges, and to supply the driving power for light trucks. When an accumulator has given up most of its stored electricity it can be "recharged".

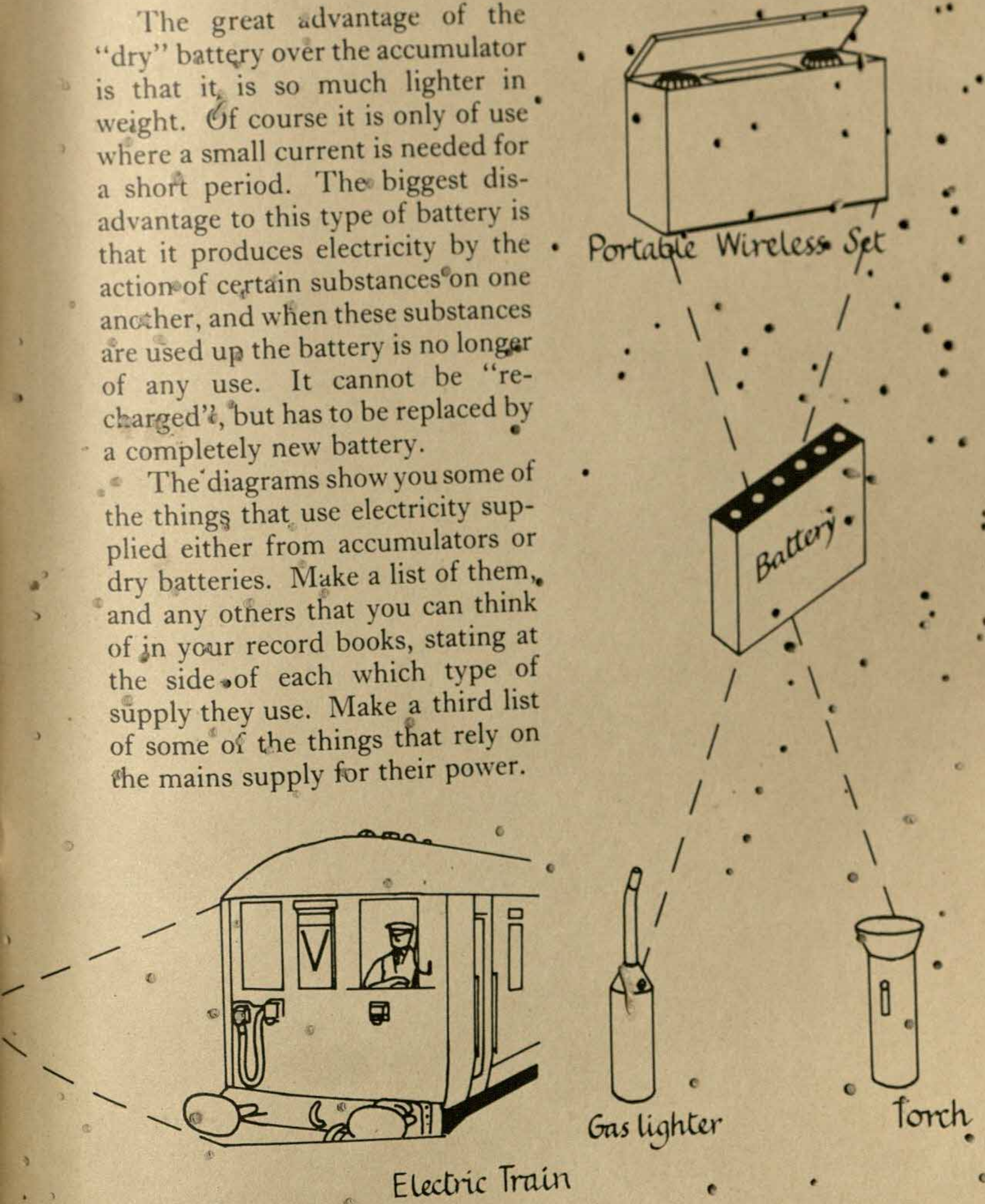
There is yet another source of electricity, the supply from a "dry" battery. This type of battery is used in electric torches, and sometimes in electric door-bells.



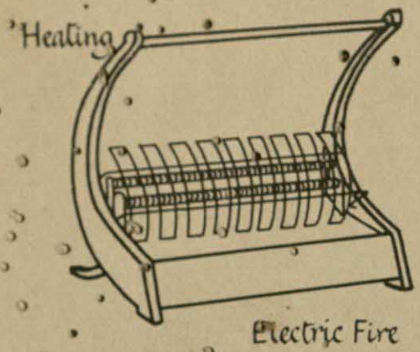
—AND BATTERIES

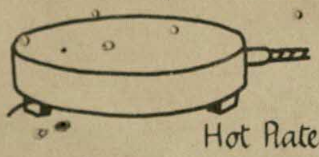
The great advantage of the "dry" battery over the accumulator is that it is so much lighter in weight. Of course it is only of use where a small current is needed for a short period. The biggest disadvantage to this type of battery is that it produces electricity by the action of certain substances on one another, and when these substances are used up the battery is no longer of any use. It cannot be "re-charged", but has to be replaced by a completely new battery.

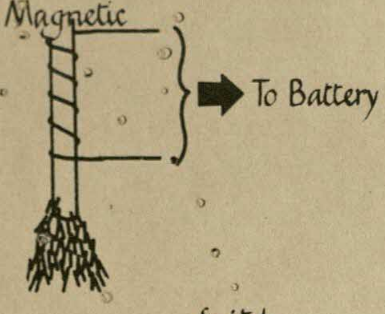
The diagrams show you some of the things that use electricity supplied either from accumulators or dry batteries. Make a list of them, and any others that you can think of in your record books, stating at the side of each which type of supply they use. Make a third list of some of the things that rely on the mains supply for their power.

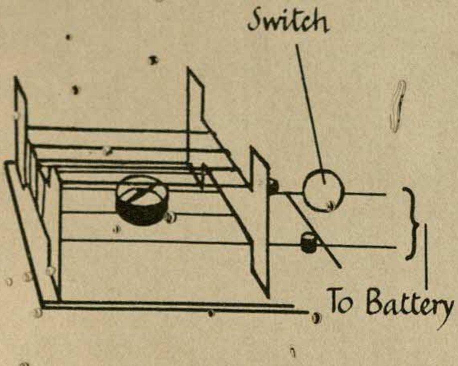


AN ELECTRIC CURRENT—









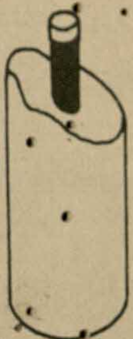
An electric current can pass along a wire or a piece of metal. We cannot tell just by looking at the wire or the metal whether the current is flowing or not. But a current can produce certain effects, and it is by these effects that we can say whether it is passing or not.

The first effect of an electric current is probably well known to you. It is that of HEATING. We make use of this effect for electric hot-plates, and for electric fires. In some cases the current is sufficient to make a wire so hot that it becomes white, as in an electric light lamp.

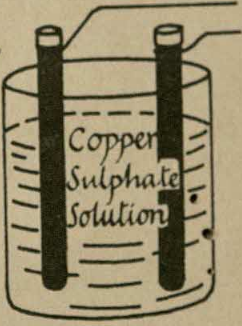
Do you remember doing an experiment with a piece of soft iron and trying to pick up some iron filings with it? You found that when a piece of cotton-covered wire was wound round the iron, and the ends of the wire were connected to a battery, and the current switched on, then the iron became magnetised and picked up the iron filings. This is the MAGNETIC effect of an electric current. We can show this in another way. Make a frame-work like the one in the picture, either of wood or cardboard. Round this wind some wire several times. Now join the two ends of the wire to a dry battery. Put a compass needle between the coils of the wire and switch on the current. What happens? Now switch off, and change the wires round on the terminals of the battery. When you have done this switch on the current again. What happens this time when the current is made to flow?

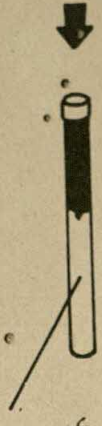
The third effect of an electric current is a CHEMICAL one. Have you ever taken an old dry battery to pieces? Inside you will find that each cell contains a rod of carbon. For our next experiment we will want two pieces of carbon like this. To these attach pieces of covered wire, with the other end of each attached to your battery terminals. Why must you remove some of the covering from the ends of the two wires? Put a solution of copper sulphate into a glass jar or beaker. Into this put the two carbon rods. Now you can switch on the current and watch closely. Can you see any copper forming on the carbon rods? If so, on which one? What happens if the wires are changed over on the battery? Where has the copper come from? This is a simple experiment and is the basis of electroplating. Later on we shall see that the chemical effect can also produce an electric current.

Chemical

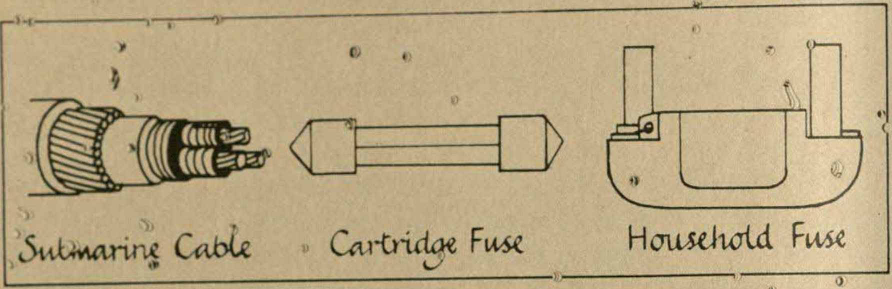


Cell of old dry battery





Plating of Copper



ALL the simple pieces of electrical apparatus have two terminals, or "leads". For instance an electric lamp has two metal contacts. The socket for the lamp has two sprung contacts. A switch has two points to which the wires are connected. Where are the two contact points on a torch bulb?

Before a current can flow there must be a complete circuit, generally made up of metal. Metal conducts electricity. To stop the electricity taking a wrong path, the wires are usually covered with an insulating material. This may be cotton, or rubber, or sometimes plastic. Wires carrying a large electric current must be thickly insulated, for example the electric cable.

Although you do not feel any ill effects if you happen to touch bare wires that are carrying a tiny current such as you get from a torch battery, the effect is very different if you touch bare wires in an electrical circuit where the source of electricity is the mains. If the current is flowing, when you touch a bare wire or the contacts of a lamp socket, the electricity takes a short-cut through you to the earth, with possibly fatal results.

Water can conduct electricity, so it is very dangerous to touch anything electrical with wet hands. It is also dangerous to have electric fires on the floor in a bathroom. The safest place for an electric fire is high up on the wall out of reach. Many switches for bathrooms are placed on the wall outside the bathroom door for this reason.

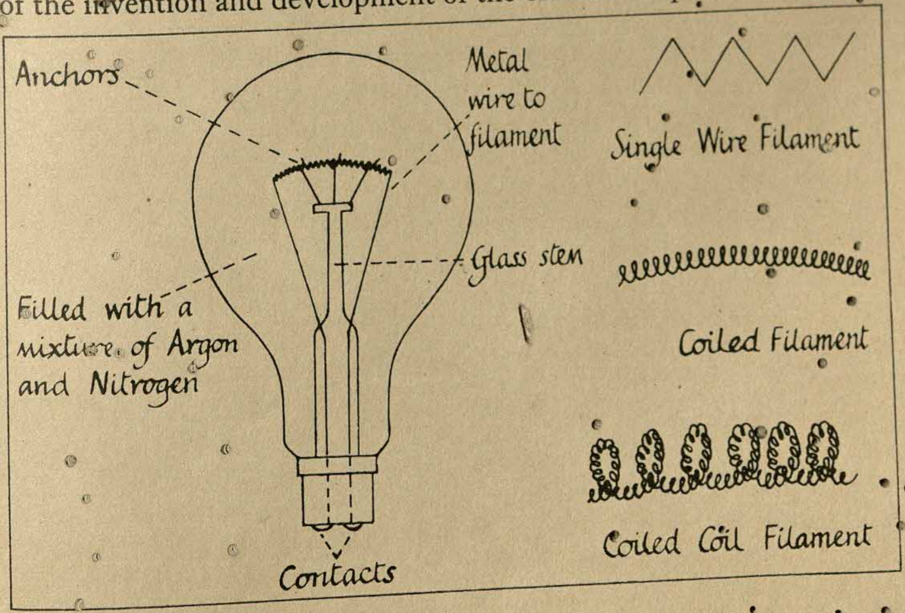
A fuse is put into an electric circuit as a safety device. If for some reason there is a sudden increase in the amount of current flowing through a circuit, damage may be done to the wiring and anything that is on the circuit is then put out of action. When a fuse is used, it is made of soft thin wire, and any increase in the flow of electricity melts this. Thus the circuit is broken and the flow of electricity cut off.

We have said that an electric current has a heating effect. The electric lamp makes use of this. The first electric lamps to be widely used had carbon filaments inside a bulb of glass. In order that the filament did not burn away, most of the air was taken out of the bulb. But this type of lamp did not give out very much light.

Nowadays the filament is made of a metal called tungsten. When a metal filament was first used it was found that the bulb gradually darkened. This happened because there was no air inside the bulb, and as the filament became heated it gradually evaporated, darkening the glass walls of the bulb. To stop this happening the lamps are now filled with argon, an inert gas.

The filaments inside the glass bulb have been improved too. At first a straight wire filament was used, and then it was found that it was better to wind the filament into a spiral. The latest improvement is the coiling of this spiral, giving the coiled-coil filament.

Two of the men who played such an important part in the invention and the development of the electric lamp were Swan and Edison. Find out all you can about them. In your record books write the story of the invention and development of the electric lamp.



AN ELECTRICAL QUIZ

IN the simple electrical circuit we used last time, there was a battery to supply the current, two wires to carry the current, and a coil of wire to show the magnetic effect of that current. If the coil is replaced with a lamp, and the current switched on then there is a heating effect. What does the word "circuit" mean?

Look carefully at the diagram of the circuit opposite and see how many of the following questions you can answer.

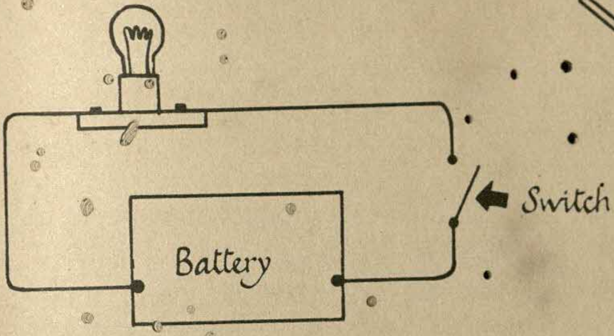
1. How many wires are joined to (*a*) the battery and (*b*) the lamp?
2. If there was only one wire to the lamp would it light?
3. When the switch is as shown is the lamp alight or not?
4. When the switch is closed, but there is a break in the wire, will the lamp be alight?
5. Instead of mending the break in the wire, could the gap be closed with a piece of metal or wood? Try this and see if your answer is correct.
6. Why is wire, used for making an electrical circuit, covered with rubber or cotton? What is this covering called?
7. Why must the ends of the wires be bared before joining them up with the battery terminals, lamp and switch?
8. Why is the heating element of an electric fire not covered or insulated?
9. Why do electricians' screwdrivers and pliers usually have insulated handles?
10. Why can birds perch on the "live" rail of an electric railway without ill effect?
11. What is the danger in using an electric fire in a bathroom?

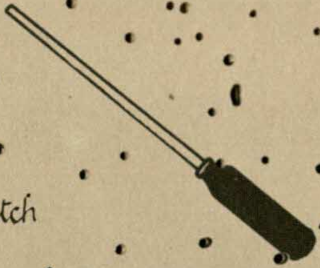
Here are some more questions. Look up the answers for next time.

1. What metals are used in fuse wire?
2. Apart from in your home, where else would you expect to find a fuse in an electric circuit?
3. What do we mean when we say "the fuse has blown"?
4. Why should you switch off the current before replacing a fuse?

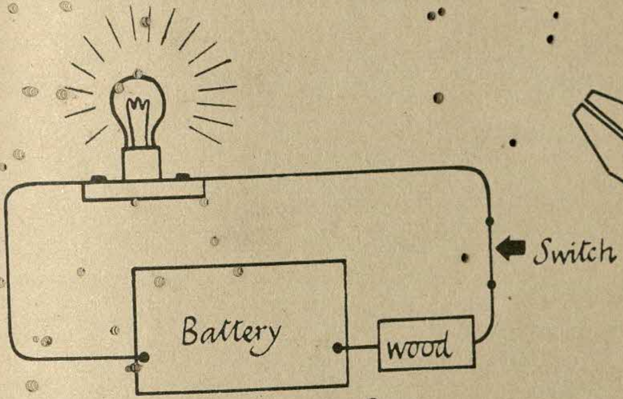
Ask your father to show you the fuse box at home. He might let you mend a fuse yourself sometimes. But whatever you do never touch a fuse box when you are alone.

AN ELECTRICAL QUIZ

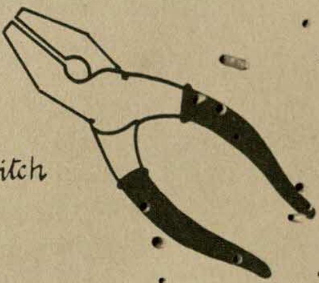




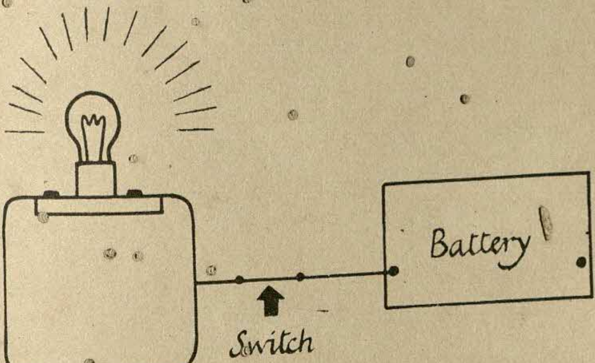
Screwdriver with
Insulated handle



Is this right or wrong?



Rubber covered
handles on pliers



Is this right or wrong?

Insulated lead

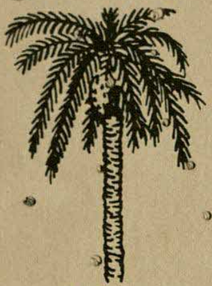
A CROSSWORD

Across

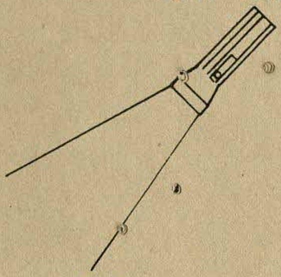
4. Short for North.
5. Mid-way between South and West.
6. This gas is lighter than air.
7. Time or a fruit.
9. Type of heating.
13. Female parent.
14. Cone of light.
15. Universal solvent.
17. Work of art.
18. Not right.
20. Type of fish.
22. Past tense of sit.
25. Fires . . . heat.
27. Smell.

Down

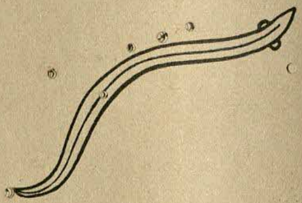
1. Instrument for measuring temperatures.
2. These vans and trains were the outcome of Faraday's work.
3. Uses a gun.
5. Short for South-East
7. Cutting for water.
8. End of an animal.
10. Exclamation.
11. Carries away waste.
12. A gas.
16. Has weight and is a mixture.
19. Used to propel boat along.
21. We hear with this.
22. Kind of bag.
23. Past tense of eat.
24. Number.
26. Verb.



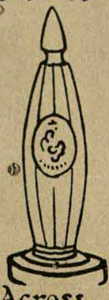
7 Across



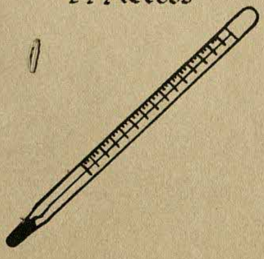
14 Across



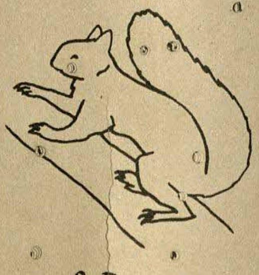
20 Across



27 Across



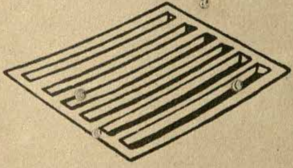
1 Down



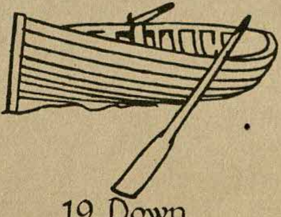
8 Down

A CROSSWORD

1 T	■	2 E	■	3	■	4	■	■	■	5	
6 H	E	L	I	U	M	■	7		8 T		■
E	■	E	■		■	■		■	A	■	■
	■	9 C	10 U	R	11 R	E	N	T	I		12 N
13 M	O	T	H	E	R	■		■	L	■	I
O	■	R	■	14			■	■	■	■	T
M	■	I	■	■		■	15 W	16 A	T	E	R
17 E		C					■	I	■	■	O
T	■	■	■	■	■	■	18 W	R	19 O	N	G
20	21 E		■	22 S	23 A	24 T	■	■		■	E
25 R	A		26		T	E	■	■		■	N
■	R	■	27		E	N		■		■	■



11 Down



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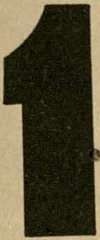


24 Down

ONE of the simplest balancing tricks that most of us have tried at some time or another is with a pole or rod balanced on the finger. No doubt you have tried, and after a little while have succeeded. But have you managed to do this without moving either your finger or hand? To do this is very much more difficult, even for a few seconds.

To balance a pencil on the flat unsharpened end is not very hard if the surface is level, like a table top, but however flat the surface, it is impossible to balance it on the sharpened point. When a pencil is balanced on a table even a slight touch on the top end is generally enough to send it toppling over.

How many of you have seen the toy that is often made in the shape of a man or a clown? However hard it is pushed it always returns to its original position, refusing to lie down. When it is standing on a flat surface which is level, and it is pushed, it may rock backwards and forwards many times, but never goes right over, and always stays on its "feet". Even if it is put on its head it always comes to rest the right way up. Have you ever looked carefully at one of these toys? Did you notice how it was made?

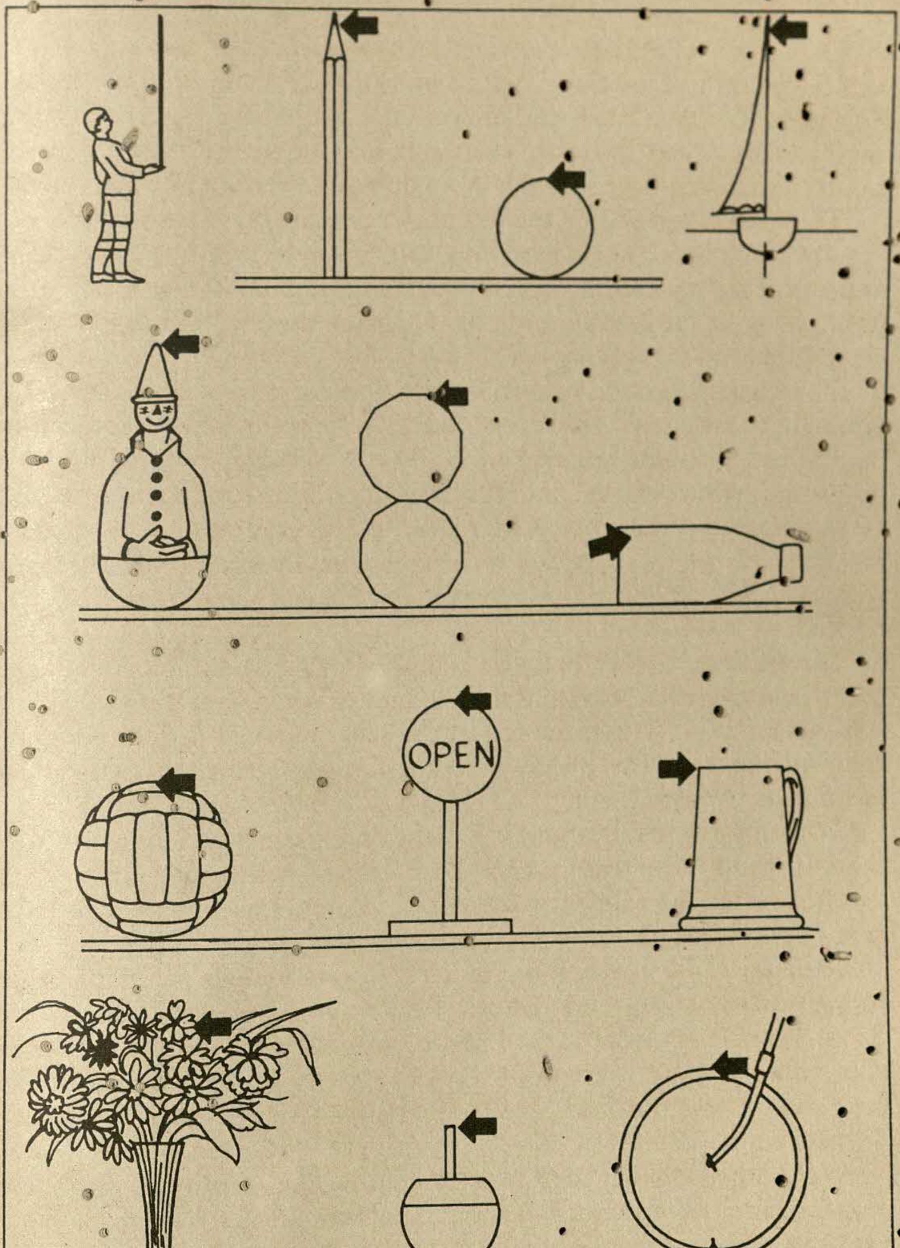
How different it is when you balance a ball on a table. As long as the table is perfectly level and flat, no matter where you put the ball, it stays where it is. When the top of the ball is moved it does not continue to move as the pencil did, nor does it return to its original position as the clown did.

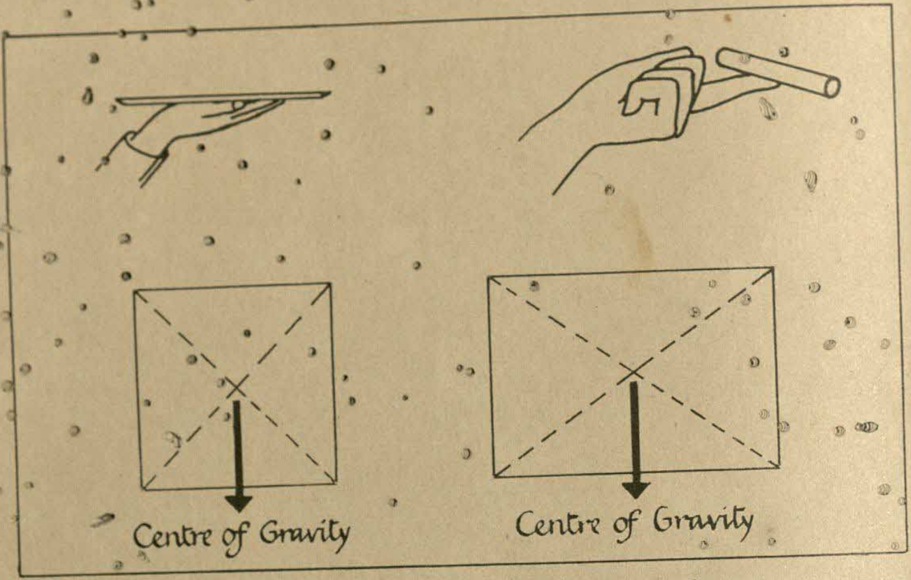
We are going to talk about balancing next time, but in the meantime can you think of a reason why the balanced pencil falls over when touched, while the ball stays where it is put, and the clown comes back to his first position?

Here are some pictures of familiar things in various positions. Can you say whether they will behave like the pencil, or the ball, or the clown, when they are touched on the top? Make copies of these in your books and put them into the three groups, those that behave like the pencil, those that behave like the ball, and those that behave like the clown.

What other familiar objects are there that can be divided into these three groups? If you can think of any others make drawings of them too in your record books and state to which group they belong.

—AND A CLOWN

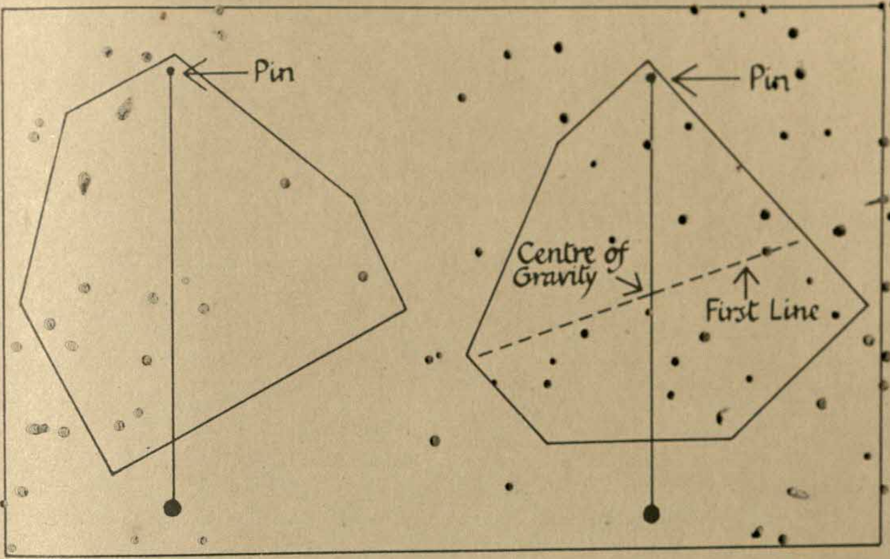




If you were asked to balance an empty tray on your hand you would almost certainly put the palm of your hand in the middle of the underside of the tray. Why would you balance it there? Although every part of the tray goes to make up the total weight of it, its weight as a whole appears to be in the centre of the tray. In the same way when you balance a thin straight rod of wood on your finger, if the weight is evenly distributed along over the rod, you rest the rod in such a way that the middle of it is on your finger. On the other hand to balance a walking stick you place your finger well away from the middle.

With all things, whatever they are made of, and whatever their shape, the weight is spread over the object. But with all of them, the weight appears to act as if it was concentrated at a certain point. This point is called the centre of weight or more usually the centre of gravity of the object. It is quite easy to find the centre of gravity of an object having a regular shape such as a cube or flat circular tray. The drawings will show you how to find the centre of gravity of a rectangle. As you see, all we need to do is to draw the diagonal lines as shown. The point at which they meet will be the centre of the figure, or the centre of gravity.

But to find the centre of gravity of a piece of card of irregular shape



we must use another method. Push a pin through one corner, and attach a thread to the pin with a small weight on the end. Hold up the card by the pin so that both the card and the thread hang freely. Mark the line of the thread on the card. Repeat this with the pin and thread at the other corners. When three or four lines have been drawn in they should meet at a point. Try to balance the card at this point on the unsharpened end of a pencil. It should balance there, for this point is the centre of gravity of this particular shape of card. Now try this again several times, using cards of different shapes. The centres of gravity that you find are the points round which the weight is most evenly distributed. They are the points about which the objects balance.

Keep all your pieces of card for later.

In this way we have found the centre of gravity of our irregular shaped cards. The same method could be used with pieces of wood, or metal, as long as they were thin sheets. It is very much harder to find where the centre of gravity is of some of the everyday things around us. We, ourselves, cannot find the centre of gravity of, say, a bus, where various materials are used. Here the centre of gravity can be calculated knowing the weights, positions and sizes of the various parts of the whole.

ANSWER THE QUESTIONS—

HERE is something for you to do. When you have completed the experiment, write it up in your record book. You will need three blocks of wood about the same size as those shown, a board, and something to rest the board on so that it is in a sloping position. Mark the blocks of wood in the same way as those shown; these marks are the diagonals, and where they cross will be a point opposite the centre of gravity of the blocks. Each block will be used in turn. To the point marked attach a short piece of thread with a small weight at the end. This is your "plumb" line.

Did you notice that the first two blocks, *A* and *B*, have the same size base, but are different heights. What can you say about *B* and *C*?

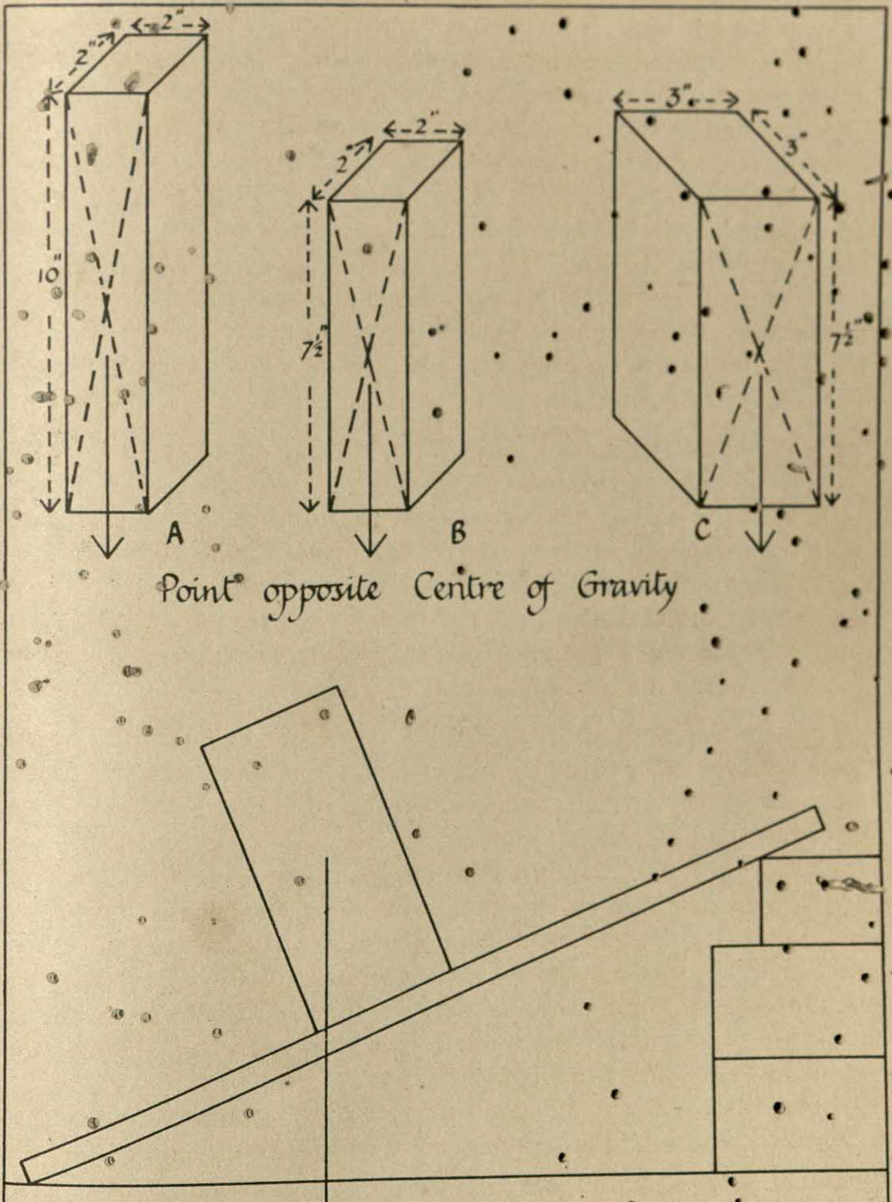
Try to answer these questions, and then do the experiment and see if you were right.

1. Which of the blocks, *A* or *B*, has the higher centre of gravity when standing on the square base?
2. When *A* and *B* are placed on a sloping board on the square base which block will fall over first when the board is tilted?
3. When *B* and *C* are standing as shown, which has the higher centre of gravity?
4. When *B* and *C* are placed on the sloping board, which will fall first when the board is tilted?

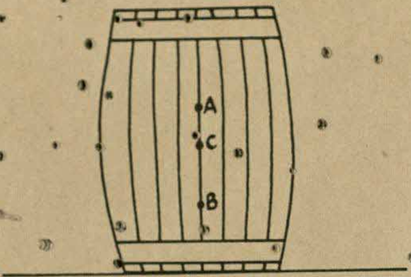
Now try this for yourselves, and measure the angle that the board makes with the table or bench, when each block of wood falls. Were your answers correct? You may have to prevent the blocks from sliding. How can you do this?

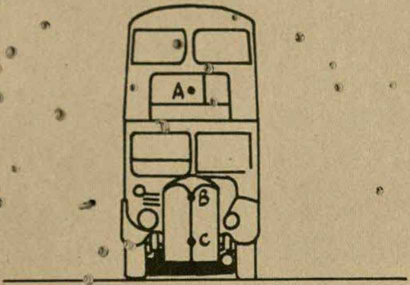
Does your "plumb" line from the point opposite the centre of gravity pass inside or outside the base when the blocks fall? You should find that the blocks fall when the centre of gravity as shown by your "plumb" line falls just outside the base of the block. At this stage the centre of gravity is no longer supported by the base, and as the centre of gravity always wants to get as low as possible it has the chance to do so, thus the blocks fall.

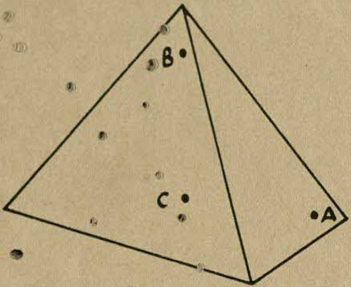
From these experiments you will see that the amount an object has to be tilted before it falls over depends on the area of the base, and the height of centre of gravity above the base. Although we have not tried it, when the base is not square the amount of tilting needed before the object falls depends on the direction of the tilt.


2"
2"
10"
A
2"
2"
7½"
B
3"
3"
7½"
C
Point opposite Centre of Gravity

WHERE IS THE CENTRE OF GRAVITY?



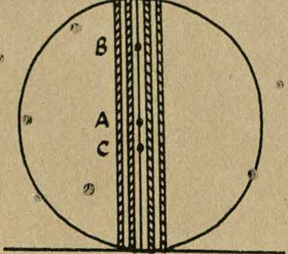


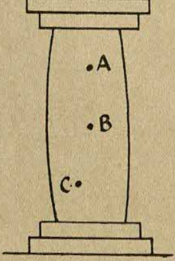


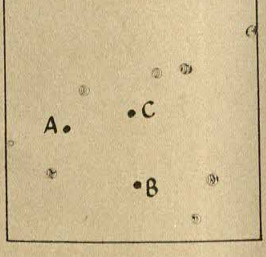
HAVE you kept your pieces of card with the centres of gravity marked on them? You will need them today. Hold them up again by means of the pins. Where does the centre of gravity come in relation to the pin? Does this happen wherever the pin is stuck in?

Using your pieces of card, still with the centre of gravity marked on each, put them flat on a table. Slowly move them towards the edge of the table until the cards overlap the edge and begin to fall. Where is the centre of gravity when this happens? Things balance only when their centres of gravity are supported. Why does not the leaning tower of Pisa fall?

Look at the drawings here. On some there are three points marked, *A*, *B*, and *C*. The centre of gravity is at one of these positions





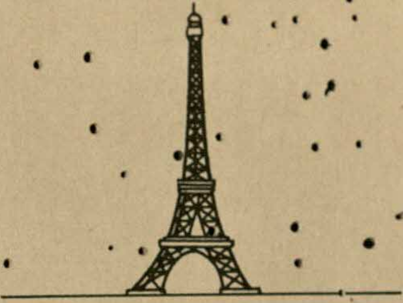


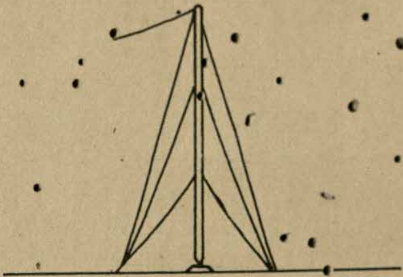
in each of the figures, can you say which?

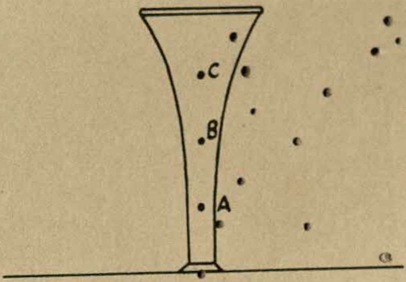
Look at the drawings again. If the top of each figure is pushed or moved a little to one side, does this raise the centre of gravity or does it lower it, or does the centre of gravity always stay at the same height?

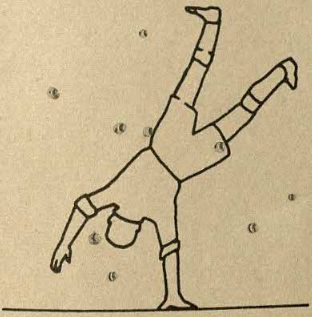
Which of the objects shown in the drawings would fall over if they were pushed at the top? At what point will they fall over? We find that most things when they are pushed or tilted enough fall over. This happens as soon as the weight of the object is no longer supported. At this point a vertical line drawn through the centre of gravity falls outside the base of the object.

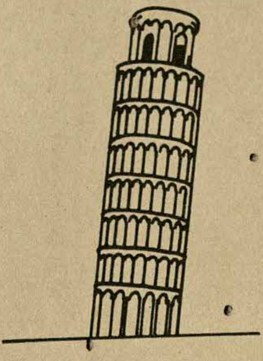
In many cases, this could happen quite easily as in the case of the wireless mast, but is prevented by the wires holding the mast in position.

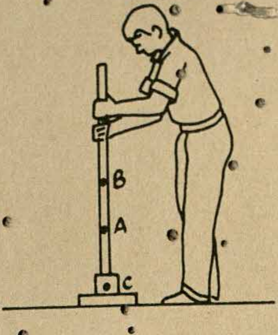












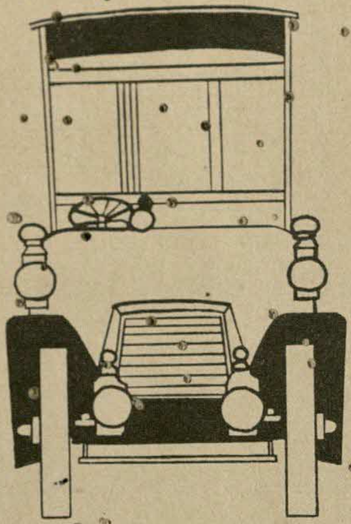
WIDEN THE BASE—

THE chances of something falling over can be lessened in two important ways. Look at the pictures of the old car and the modern one. In which is the centre of gravity low, and in which is the centre of gravity high? Which of the two cars is more likely to topple over when taking a corner fast? Why do you think so?

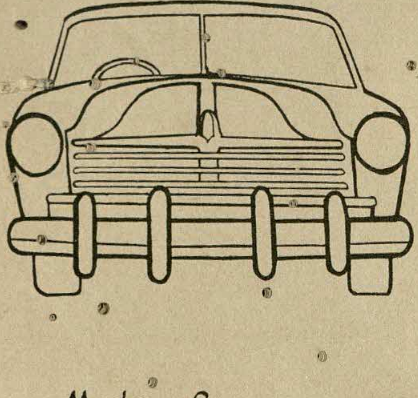
To make a car more stable, that is, less likely to overturn, the centre of gravity is made to be as low as possible. By lowering the centre of gravity we can lessen the chances of a "body" falling over.

At times it can be very annoying to be told that there is "No standing allowed on top" on a bus. But there is a reason for this order. Can you say what it is?

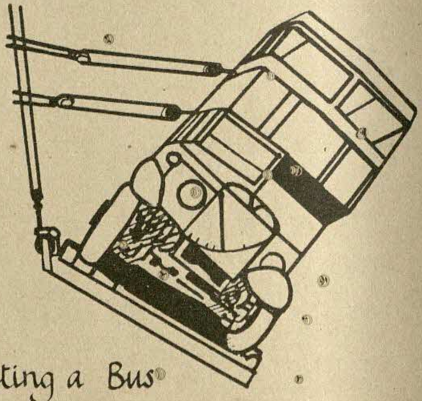
There is much less chance of a



Old Car



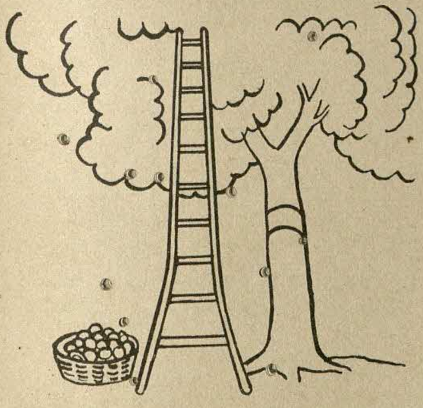
Modern Car

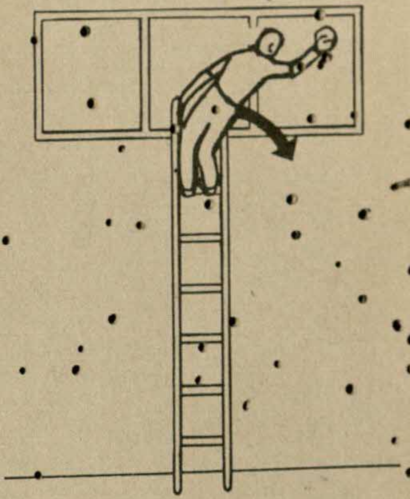


Testing a Bus

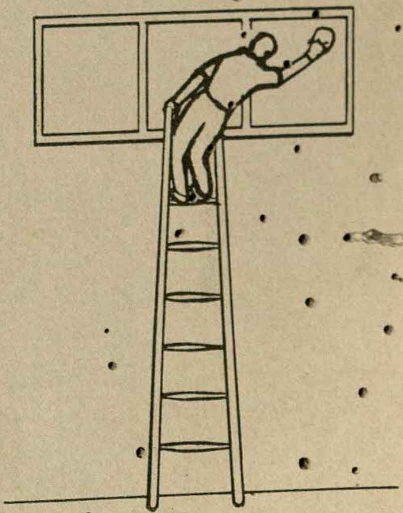
car going over forwards or backwards than there is of its overturning sideways. Why is this?

Here is a second way of lessening the chances of a "body" falling over. Fruit pickers use a ladder which is perhaps different from the usual ladders we see. Do you know what is different about it? When fruit is being picked in the orchards, the pickers have to reach out sideways to reach much of the fruit. When they are near ground level, there is not very much danger because the centre of gravity is always supported, but the higher they go up the ladder the greater is the chance of falling sideways. To enable the pickers to lean out sideways even when they are on the top of their ladders, the bottom of the ladders are made much wider than the top. This keeps the centre of gravity over the base.



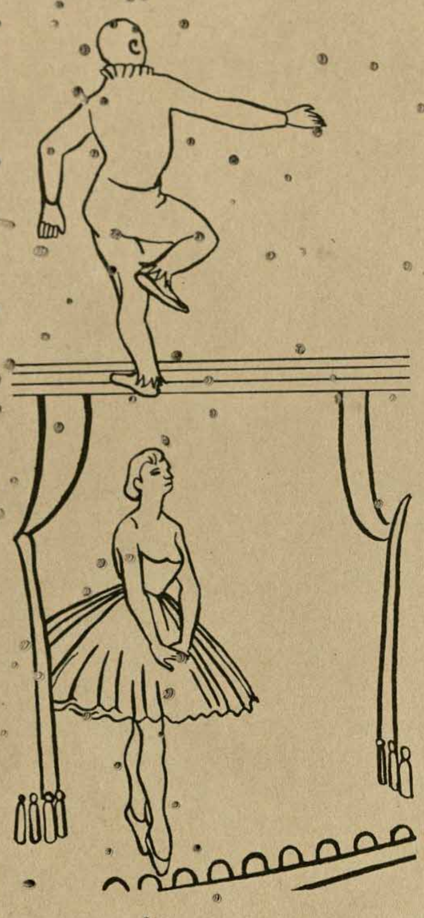


Centre of Gravity is outside the base



Centre of Gravity is over the base

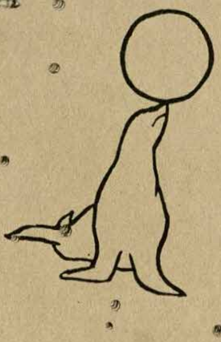
THERE ARE MANY EXAMPLES—



THE question of balance and centre of gravity is just as important to you and to animals, as it is with such things as buses and ladders.

Man naturally stands on two feet and can remain that way for long periods without any real effort on his part. This position is accepted without thinking. How different when he stands on one leg only. He often has to hop about to avoid falling over. His problem is rather like that of the fruit picker. The wider the base of a body the more stable it is. This means that the body can be tilted quite a way before the centre of gravity becomes unsupported by falling outside the base. Man standing on two legs has a much larger area touching the floor than when on one leg. Because of this he can lean over more when on two feet without falling over than when on one foot.

The ballet dancer, when she is "on her points", performs a very difficult feat of balance for the area touching the ground is very small indeed, and the balancing needs a great deal of practice.



Animals, find it very much harder to stand on two feet, instead of the normal four. A dog or an elephant is very stable when standing in the usual way on four legs,

—OF BALANCE IN THE CIRCUS

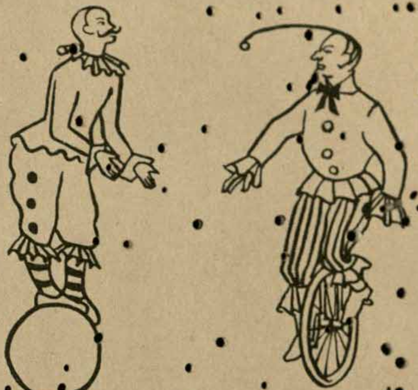
but sometimes they are taught to stand on two legs, and then they are usually quite wobbly.

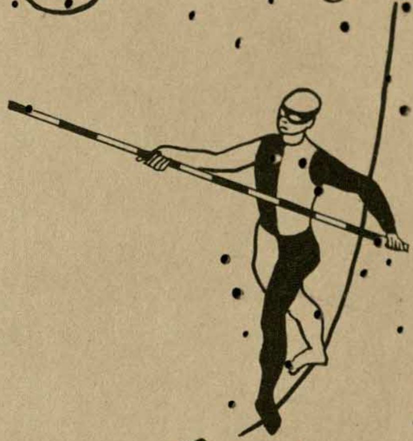
When a body is tilting, so that there is danger of the centre of gravity being unsupported by no longer being over its base, there are two things that can be done to keep the body from falling. Either push the body in the opposite direction of the tilt, or move the base. When you try to stand on one leg and feel yourself going over, and yet you do not want to put the other foot to the ground, what do you do to keep from falling? You move your foot a little, or do a little hop, so that once again your foot is under your centre of gravity. Have you ever watched a dog do this when being taught to stand on its hind legs?

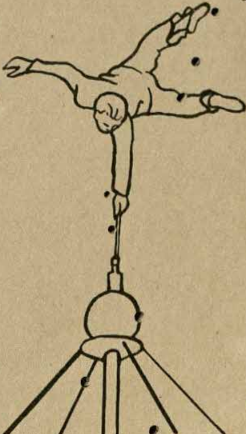
Many of the circus acts involve clever feats of balance, for example the wire-rope walker who often carries something like a pole or an umbrella. In what way does this help him to keep his balance?

When an artist balances on one spot as he is doing in the bottom drawing, you will have noticed that only the slightest of movements of the arms and legs are sufficient to alter his balance.

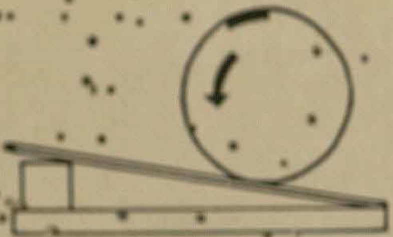
Draw or paint a circus scene showing some of these feats of balance.







TRY MAKING THESE

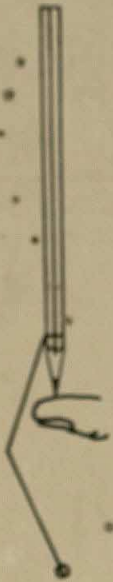


The Ring that runs up a slope

MANY simple tricks and toys make use of balance and gravity. We have already mentioned one, the clown that will not lie down. You can probably think of others. Later on this year, I hope you will organise another exhibition, and if you do you should certainly include some examples of balancing. Here are one or two. You may have come across them before, and be able to think of others.

The ring that runs up a slope.

Make a ring of cardboard or thin celluloid about fifteen to eighteen inches in diameter. On the inside of the ring attach a small piece of lead, and then put the ring on a gentle slope in the position shown. By altering the slope you will find a point where the ring runs uphill. Can you explain this?



Balancing a pencil on its point

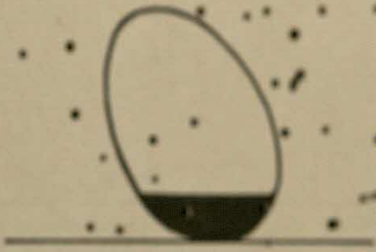
Balancing a pencil on its point.

Although it is impossible to make a pencil balance on its point in the ordinary way, we can do it by making use of what we have found out about the centre of gravity. Look at the diagram, it explains itself. But can you say why the pencil balances in this way?

SOME TRICKS OF BALANCE

The egg that balances anywhere (or almost anywhere).

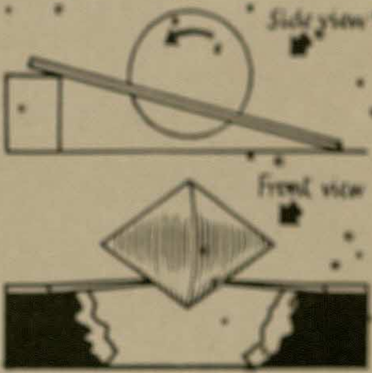
Next time your mother is going to use an egg for cooking ask her if you may blow it by making a tiny hole at each end. In this way the shell will remain whole. You can then wash it out to clean it, and allow it to dry. When you have done this put some fine sand inside so that it is about a quarter filled and then seal the holes. Now see in how many positions you can balance it. Can you explain this?



The egg that balances anywhere

The double cone that seems to run the wrong way.

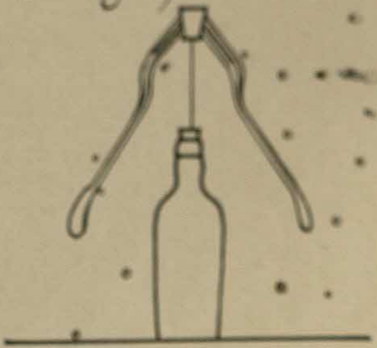
For this you will need a double cone as shown made of wood. If you can get one place it on a slope made of two rulers as shown. By altering the position of the rulers, it appears that the cones run uphill. What actually happens is that although the cones seem to go uphill, they in fact fall lower and lower between the rulers.



The double cone that seems to run the wrong way

Balancing a needle on its point.

Earlier on we said this was impossible. But can you see from the diagram how and why it can be done?



Balancing a needle on its point

THE STORY THE PLANTS TELL

OUR islands are quite small in area when compared with other countries such as the U.S.A. and Canada, yet even in Britain the scenery is not the same everywhere. You may have noticed this when you have been on holiday. Maybe the soil where you live is chalky, or perhaps sandy. If your district is chalky and you have taken a trip to a sandy district, you will have noticed several differences.

The different types of soil will mean there will be different kinds of plants. Do you remember how we said the soil is formed? If the parent rocks are not the same we cannot expect the soil that comes from them to be the same. One of the most interesting guides to the type of soil in any particular area is the wild plant life, and if the area is agricultural the kinds of plants cultivated there.

Can you think of any plants that grow and flourish in sandy districts? Would you expect to find pine trees or oak trees there? A sandy soil generally holds less water than, say, a clay soil. Which area, clay or sand, would you expect to suffer most from a drought?

Water is essential to plant life, though some plants need less than others. Water taken up by plants passes through them and evaporates through the leaves into the air. Plants growing in a sandy district cannot afford to lose as much water in this way as a plant that grows in a clay district. Since water is lost through the leaves of plants can you say which will have the smaller leaves, those that grow on sand or those that grow on clay?

On light sandy soil we find such plants as the pine tree, heather and gorse. On heavy clay soil and soils that are generally wet, other types of plants are found, trees like the oak and wild flowers such as the buttercup. Which has the larger leaves, the buttercup or heather? The oak tree or the pine? Does your answer agree with what we have said about the amount of water in the soil and its evaporation through the leaves?

Here is something for you to do. Make a large map of the area around your school marking on it the different areas, sandy soil, clay and chalk and so on. Use different colours for these and at the same time mark on them whether they are dry or moist soils. On another map of the same area, mark in the types of trees and wild plants to be found there. Even if you live in a town you can still do this.

TAKING WATER TO THE LAND

AS the population of the world grows so the amount of food needed to support all the people increases. Apart from making the existing areas produce more food, areas that at one time were allowed to lie waste are now being brought into use. Whether a region will produce crops that we want is often dependent on the dryness or otherwise of the soil there. If a region is too dry or too wet, it can in some cases be changed.

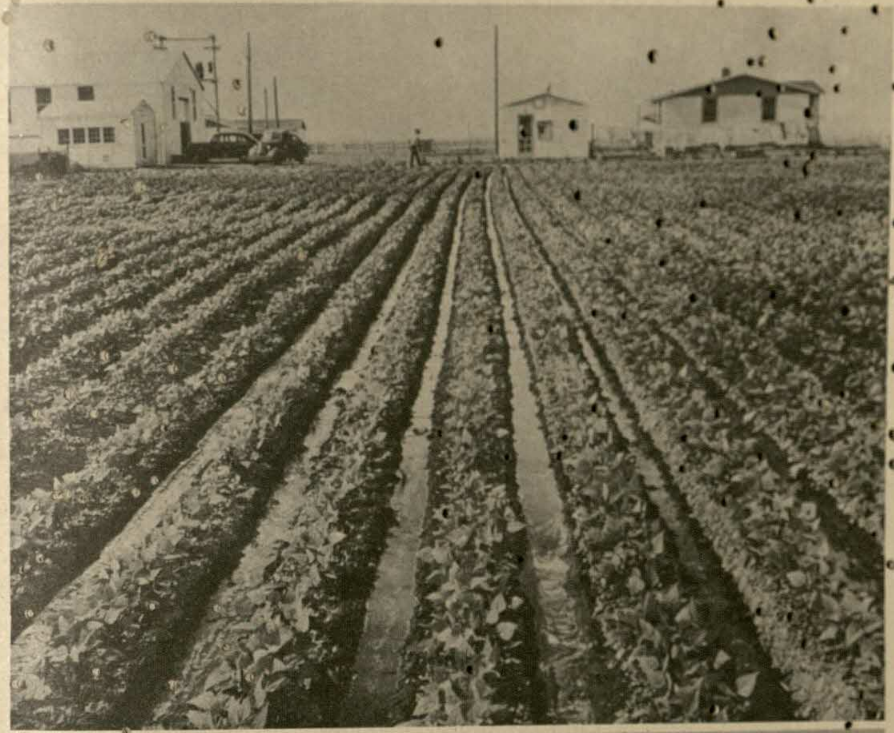
In Britain, there are dry sandy areas and wet marsh lands, but fortunately they are not extensive. But in some parts of the world there are vast areas of desert or damp, low lying ground. As in our islands, these differences can be seen by the different kinds of plants growing there. You will have seen pictures of deserts and the weird shapes of cacti that grow there. These strange plants are so designed by Nature to live under very dry conditions.

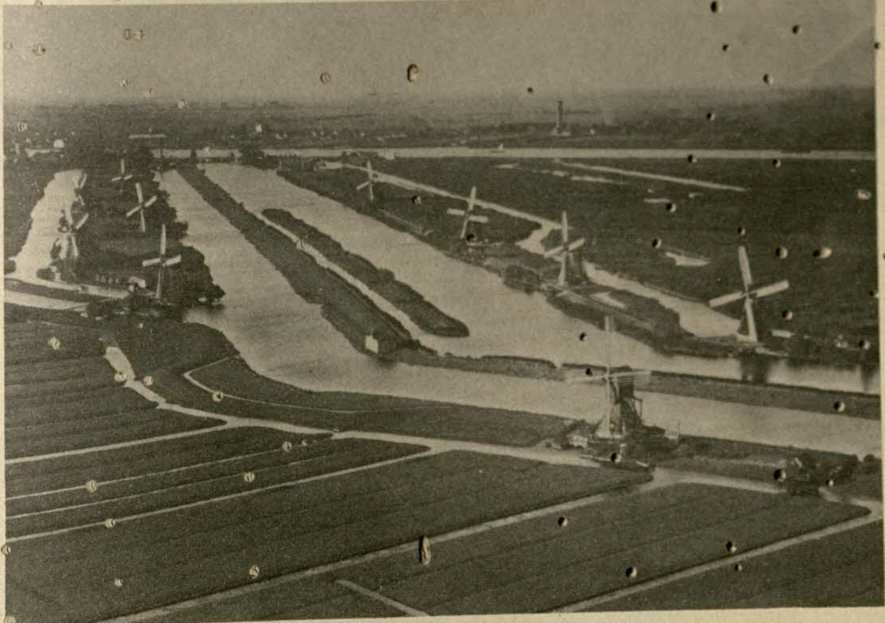
The other extreme to the desert is the vast areas that are nearly always under water, and because of this the plant life is very different. Where would you expect to find such swamps? What type of plants grow there?

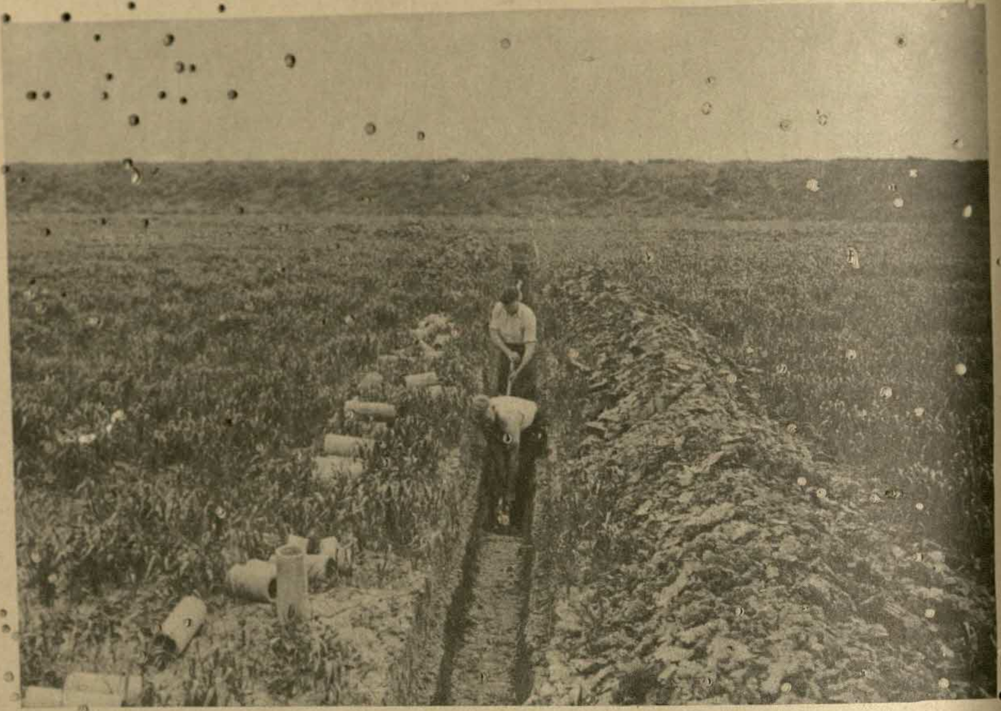
In less extreme parts of the world it has been possible for man to change the natural conditions, making them wetter or drier as he desires.

Some countries have soil which could grow good crops but for the fact that it is too dry. In some of these cases the amount of moisture has been increased by artificial means. An example of this is the area of Salt Lake City in the U.S.A. There is very little rainfall there, and yet today it is a very fertile land. This has been done by a system of irrigation. Do you know any other parts of the world where irrigation has made the dry earth produce crops?

In Eastern Holland, which is higher than Western Holland, the soil is either sandy or marshy, while in the west the ground is mostly below sea-level. Here the soil is most fertile, but useless while under water. But the land has been drained by making canals, not to carry the water to the land as in the case of irrigation, but to carry the water away from the land. Water is pumped into the canals, using the power of the wind for the pumps. This is yet another example of man's use of the wind. The land is reclaimed, and is made to produce crops. Do you know of any other areas in the world where land has been reclaimed?





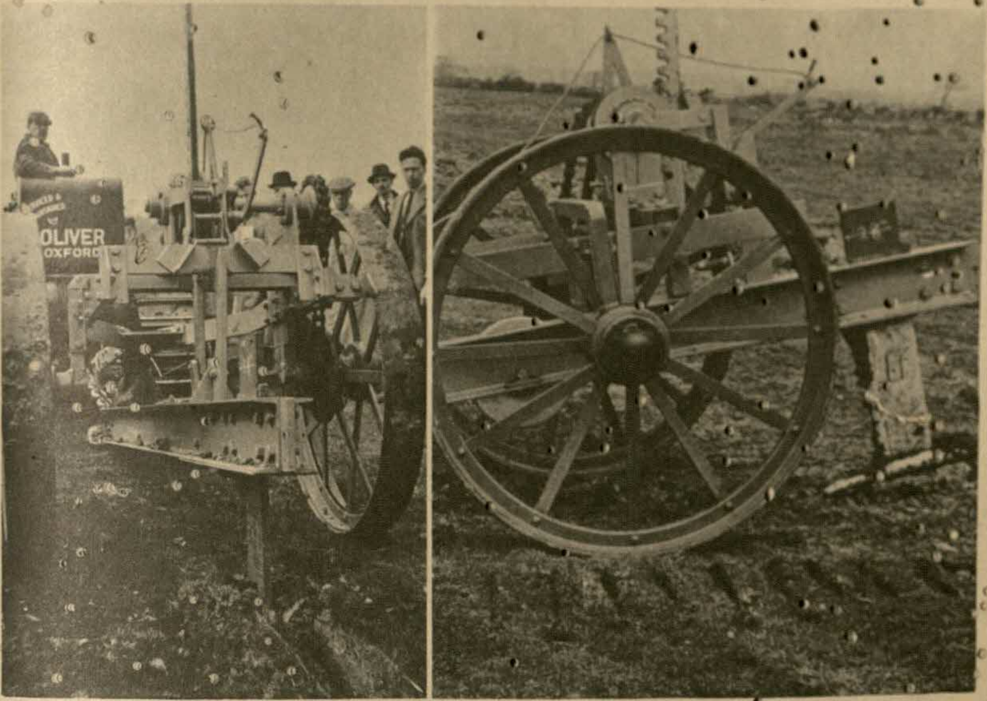


DRAINING AND DITCHING—

ALTHOUGH everything that a plant needs in the way of moisture and food may be ready in the ground for it to thrive on, few, if any, of the cultivated plants will grow without attention. If the soil is heavily cultivated, plant foods will have to be added, unwanted plants will have to be removed, the soil will have to be turned over every so often for fresh planting. To get the best results the farmer must look after his land and plants all the time. There is always something to be done, ditching and draining for example, especially on the heavier soils such as clay.

Without a proper drainage system, many of the heavy clay soils might become waterlogged. Do you know what this means?

One way in which soil is sometimes drained is by using earthenware pipes. A series of trenches are dug in such a way that they run in the same direction as the slope of the land. In these trenches, earthenware pipes are laid, and although one long line of pipes is



—FOR WATERLOGGED SOILS

formed, the ends of the pipes are not joined. When the pipes have been laid, the earth is replaced in the trench. By this means water is drained away from around the pipes and from some distance away as well.

Another method that is sometimes used is called "mole drainage". A steel mole is dragged through the earth at the required depth and as it goes it leaves behind a hollow channel. Although there are no walls to these drains as there are in the case of the earthenware pipes, they stay open for quite a long time and they have the advantage of being much cheaper.

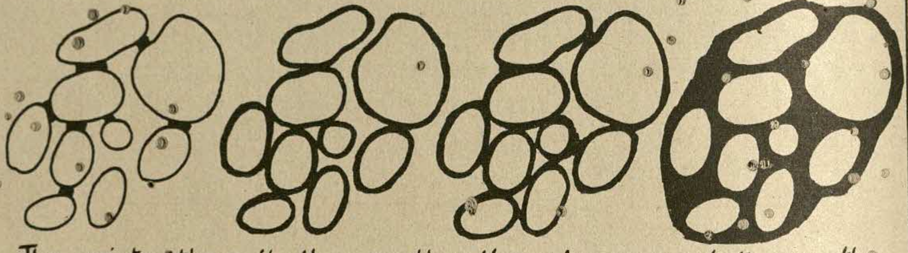
Ditches are often dug so that surface water from the fields may drain into them and so run away. Water from pipe drains and mole drains too, is taken away in these ditches. It is extremely important that these ditches should be kept clear, otherwise they become blocked and the fields remain waterlogged.

SOME SIMPLE EXPERIMENTS—

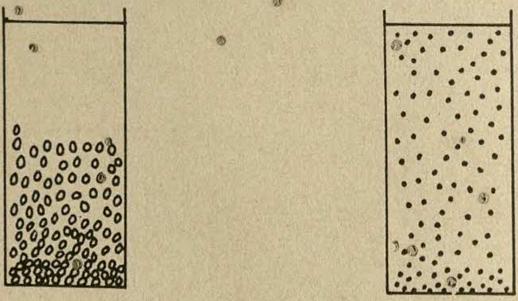
WE know without a doubt that soil can and does hold moisture, but we do not know how the amount varies with different types of soil. Here are some experiments for you to do with a tinful of damp soil. First weigh it and make a note of the weight. Now allow the soil to be dried by the air and then weigh it again. When you have done this compare the two weights. Now dry the soil in an oven at 100° C. and take the weight agian. How do the three weighings compare? What explanation can you give for the results you have obtained?

When equal weights of air-dried clay soil and air-dried sandy soil are taken and then dried in an oven we find that the clay loses more weight than the sand. This shows that air-dried clay can hold more water than air-dried sand. Why is this?

Here is an example to help you understand. If we take a large cube of wood and cut it up into many smaller ones the total surface



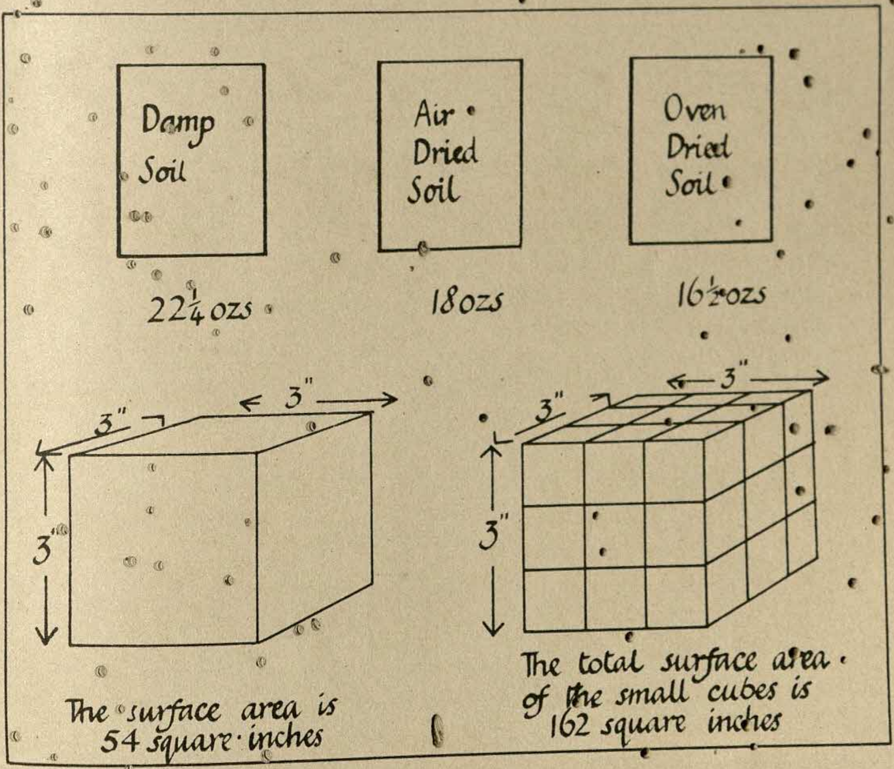
The moister the soil the smaller the air spaces between the particles. When the soil is waterlogged there are no air spaces.



Coarse particles of sand sink quickly
Fine particles of clay sink slowly

area of the small cubes will be very much greater than the area of the large one, although the weight of the wood is the same. Water that remains in air-dried soils is held on the surface of the particles of the soil. When the sizes of sand particles and clay particles are compared we find that those of the clay are very much smaller and therefore there is a larger surface area, and so the clay holds more water. You can test this for yourself quite easily. Shake up some clay and some sand separately with water in tall tubes or measuring cylinders and allow them to stand. Which settles out first, the clay or the sand? The larger and coarser particles of sand settle first, while the finer particles of clay take very much longer, and the water may remain cloudy for several days.

If you can get samples of other types of soils, try these experiments on them, and see how the results compare with those you have already obtained.


Damp Soil
Air Dried Soil
Oven Dried Soil
22¼ ozs
18 ozs
16½ ozs
3"
3"
3"
3"
3"
3"
The surface area is 54 square inches
The total surface area of the small cubes is 162 square inches

MORE EXPERIMENTS—

LAST time we did some simple experiments with clay and sand. Today we are going to do some more of these experiments.

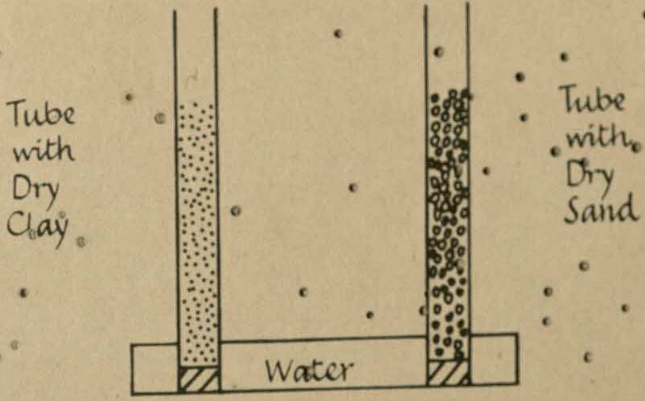
For the first one you will need two long glass tubes of the same diameter open at each end. Close one end of each tube with a plug of glass wool, you can use cotton wool, but glass wool is better. Pack one tube with air-dried clay and the other with air-dried sand. Now stand them in a bowl or basin of water, with the plugged end downwards, and watch what happens. Water should rise in both tubes. In which one does it (*a*) rise more quickly at the start and (*b*) rise the higher?

Water rises through particles of soil in exactly the same way as paraffin rises through the small spaces between the fibres of the wick in a lamp. In just the same way when a lump of sugar is put into a small amount of liquid the liquid rises to the top of the sugar.

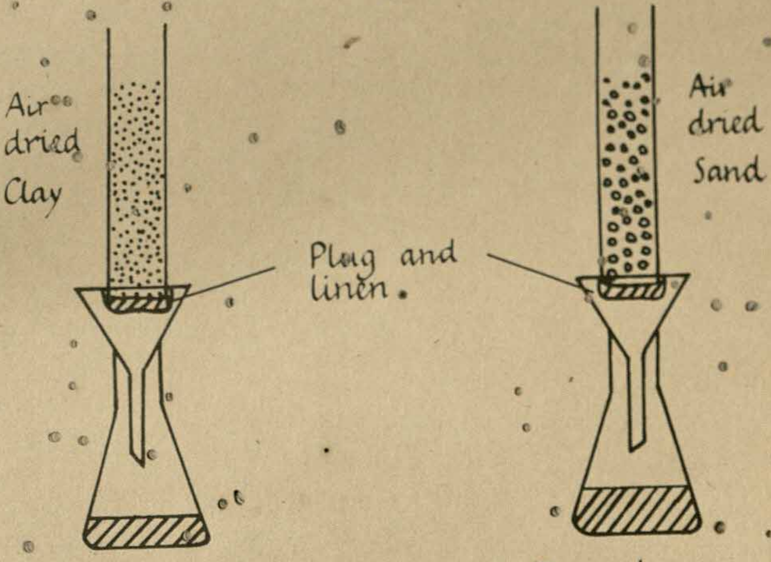
Put equal quantities of air dried clay and sand into two glass tubes of the same diameter as shown in the diagram. Before putting in the soils close one end with pieces of linen and plugs of glass wool. Now pour equal amounts of water on to the clay and sand and allow it to drain through, collecting it at the bottom. Pour the water that has collected at the bottom back on top of the clay and sand. From this experiment you will see which type of soil can hold most water, the clay or the sand. Now both of your tubes of soil are moist. When the water has drained through take two more equal quantities of water and pour on top of the two columns of soil. Water can pass through both of these moist soils, but goes through one of them faster than through the other. Can you say which? Wet clay allows water to pass through it much more slowly than does wet sand.

Can you answer these questions?

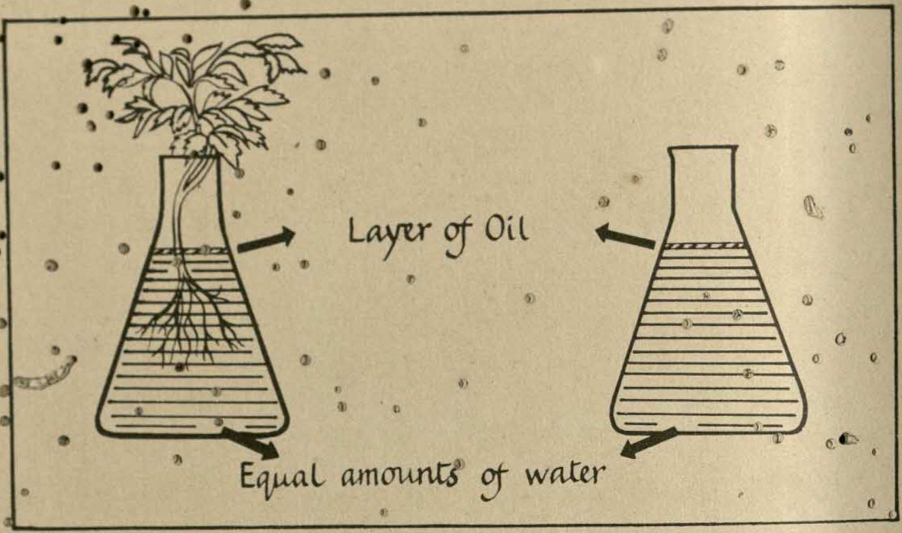
1. In warm weather which kind of soil loses more water vapour to the air, clay or sand?
2. Why does water rise through clay soil but not sandy soil?
3. Why does raking and hoeing a clay soil cut down the amount of water lost?
4. What other ways are there of lessening the loss of water by evaporation?



The water rises *faster* at the start in one
But rises higher in the other



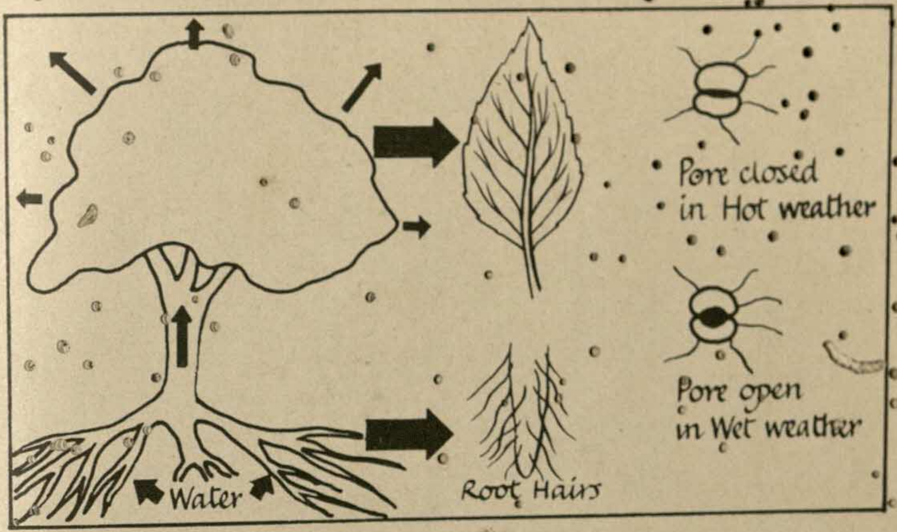
This water has drained through



EVERYBODY knows that plants need water, but there is no way of telling just how much they need in the ordinary way. To find this out we have to do small-scale experiments and take careful measurements. Into two jam jars or flasks put equal quantities of water. Add to this a little oil so that a thin layer is on top of the water. This prevents loss of water by evaporation to the air. Mark the level of the water on the two jars. Into one suspend a small plant as shown in the picture, the other jar leave as it is. Now you must watch the levels of the water in both jars and note any difference you see. This will have to be done over several days for the best results to be obtained. Can you explain what you have noted?

Look closely at the roots of the plant and you will see that they are covered with lots of tiny hairs. It is through these that water is taken up into the plant. The outer skin of the root hairs stop any solid particles from entering. The water gradually rises through narrow tubes in the plant or tree until it reaches the leaves and flowers. This is similar to the way water rises in a column of soil, or the way liquid will rise through a lump of sugar. The rising of any liquid in this way is called capillarity.

We can show this rise of water through a plant in another way. Take a freshly cut white flower such as a marguerite and stand it in a



jar of water which has been coloured with some red ink. Watch the flower over a period of a few days. What do you see?

Water rising in a plant travels along certain channels in the plant. Plants do not soak up water in the way that blotting-paper will. Can you suggest a name for the channels in plants?

Water which rises to the leaves of plants escapes to the air. If you have a microscope you can examine a leaf under it and you will see hundreds of tiny holes on the underside of the leaf. These are called stomata, which means "mouths". The "mouths" can be widened or narrowed by the plant and so the amount of water escaping to the air can be controlled by the plant. When the weather is hot the stomata are smaller than in cold weather, and therefore less water vapour escapes into the air. If too much escaped the plant would soon wilt.

Take two lilac leaves and smear a thin coating of Vaseline on the upper surface of one and on the underside of the other. Lilac leaves have stomata only on the underside of their leaves. Watch what happens and try to explain it.

Cover a flower pot, with a plant growing in it, with waterproof material, so that no moisture can escape from the pot or the soil. Now cover the plant with a glass jar, standing on a glass plate. Can you explain the appearance of moisture on the glass the next day?

THERE ARE LATE SOILS AND EARLY SOILS

WE have said that water evaporates from the soil, and that clay soils lose more water to the air than sandy soils. We can cut down this loss of moisture from the soil by raking and hoeing. This breaks up the narrow channels between the particles of soil through which the moisture rises from below. Water cannot rise if the channels are too large. The layer of loose soil between the air and the moist layers is called a mulch. Sometimes grass cuttings or straw are spread over the surface of the soil to form a mulch and so cut down the evaporation of moisture to the air.

To evaporate water needs warmth. This warmth is taken from the soil, and therefore the soil is cooled. Which kinds of soils lose most moisture to the air? Which soil will be the cooler? Is there anything else that causes moisture to evaporate? Could the wind do it?

All plants need a certain amount of warmth for proper growth, just as all seeds need some warmth before they will start to grow or germinate. There are other things that affect the growth of a plant but temperature is the most important.

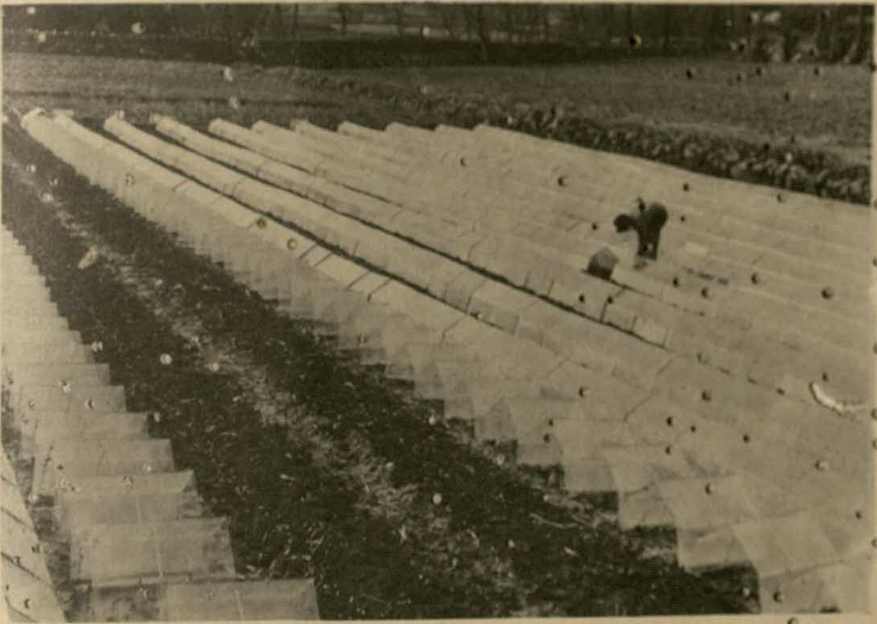
A clay soil will take longer to warm up in the spring than a sandy one, but on the other hand it takes longer to cool down when autumn comes. That is why such soils are called either cold soils or late soils. Which types of soils will give early crops and which ones will give late crops?

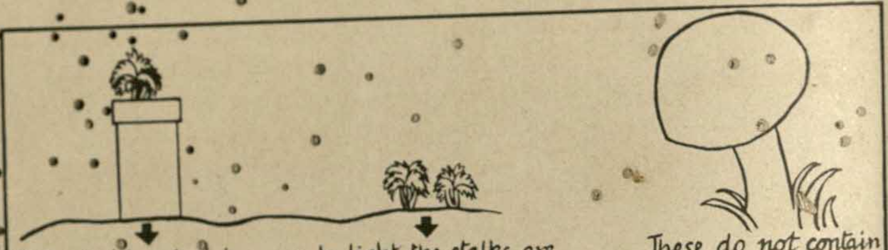
Windbreaks help to protect the soil by lessening the force of the wind. This cuts down the chances of erosion and also the amount of moisture the soil loses to the wind.

If there is much cloud in the sky by day then the amount of heat from the sun that reaches the plants and the soil is cut down. At night they will lessen the amount of heat that the soil will lose by radiation.

If you wanted to raise seeds other than in the open ground how would you do it? Many gardeners use small glass covers or cloches as they are called. Sometimes a cold frame is used.

Many of the plants grown in this country came originally from warmer countries abroad. Very often the temperatures out of doors even during the summer in this country are not high enough for these. Even if they did survive the summer here, many of them would perish in our winters. How can we look after them so that they will continue growing here?





Celery is blanched by keeping the light from it

In light the stalks are shorter greener and tougher

These do not contain Chlorophyll

HAVE you ever planted a bowl of bulbs and put them in a dark place to start them off? As the bulbs send up the leaves you will have seen that they are not green but quite white in colour. Later when they are brought out into the light, a change takes place. What happens to the colour of the leaves? If the growing plant had been left in the dark it would soon have become tall, thin and very spindly. After a while it would die. Do you remember we said that bulbs are the swollen leaves of plants and this swelling is food stored for the plant to live on in the following growing season? As soon as this food is used up the plant normally begins to make more, but if it is kept in the dark it cannot do this. Why do you think this is so? Perhaps you grow celery at home. Why is the soil heaped up round the stalks of the leaves? Sometimes pipes are used instead.

As soon as the plants that have been growing in the dark are moved out into the light the leaves change colour and become green and the plant begins normal growth. Therefore we conclude that light is necessary for plant growth, to make it healthy and green, and to give them the chance to make plant food.

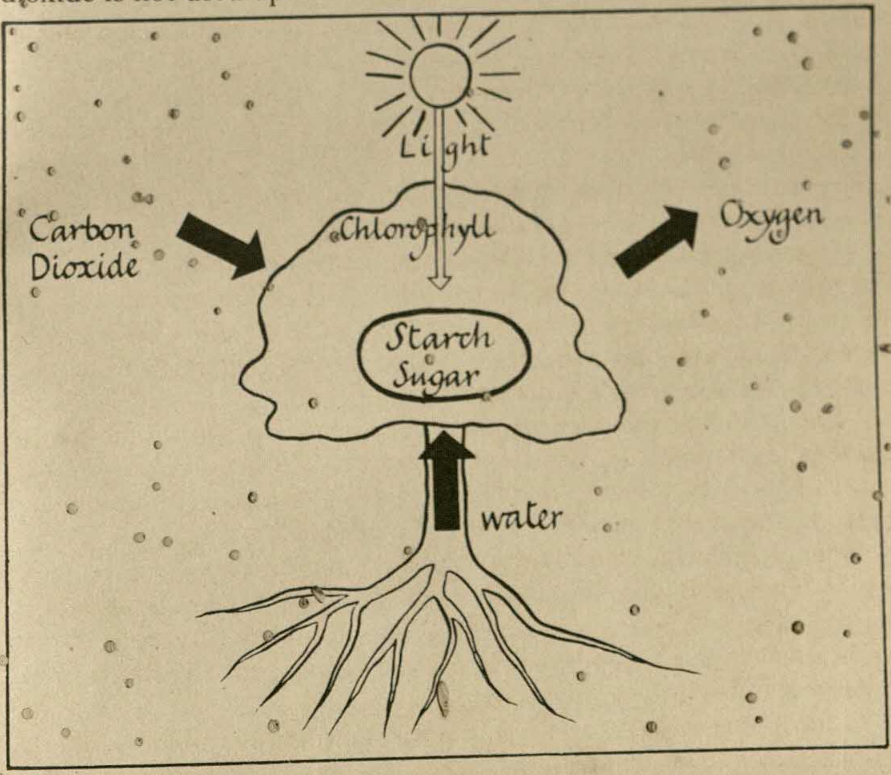
The green substance in plants is called chlorophyll. Some plants such as mushrooms and toadstools do not contain this substance but most of them do. Plants that do not have chlorophyll cannot make their own food, but have to take it in already made.

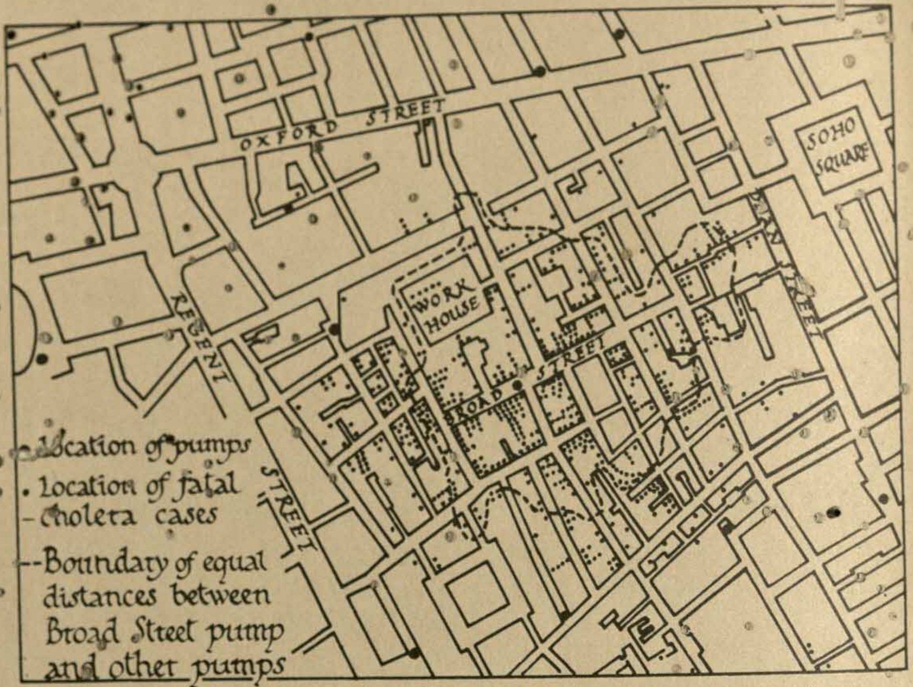
Plants "breathe" too. During the daytime the leaves take in large amounts of carbon dioxide as well as a little oxygen. Carbon dioxide is the gas that is made when things like wood and coal are burnt. At night, the leaves no longer take in carbon dioxide, only a little oxygen, breathing out a little carbon dioxide.

Chlorophyll helps a very important change to take place inside the plant during the hours of daylight. This green substance with the aid of light turns the carbon dioxide and water into other substances. These are called carbohydrates because they contain carbon, hydrogen and oxygen. Both sugar and starch are examples of carbohydrates and both are found in plants. The plant uses these carbohydrates for food. While this change is taking place a large amount of oxygen is released from the carbon dioxide, and as the plant has no need of this gas it is breathed out. Therefore during the daytime the plant breathes in a little oxygen through the leaves but breathes out far more.

Plants need other things as well, and one of these is nitrogen. Substances containing nitrogen are taken in with the water from the soil. Often these have to be put there especially if the soil is continually growing things. We shall come back to plant foods later.

With all the plants there are why is it that the supply of carbon dioxide is not used up?



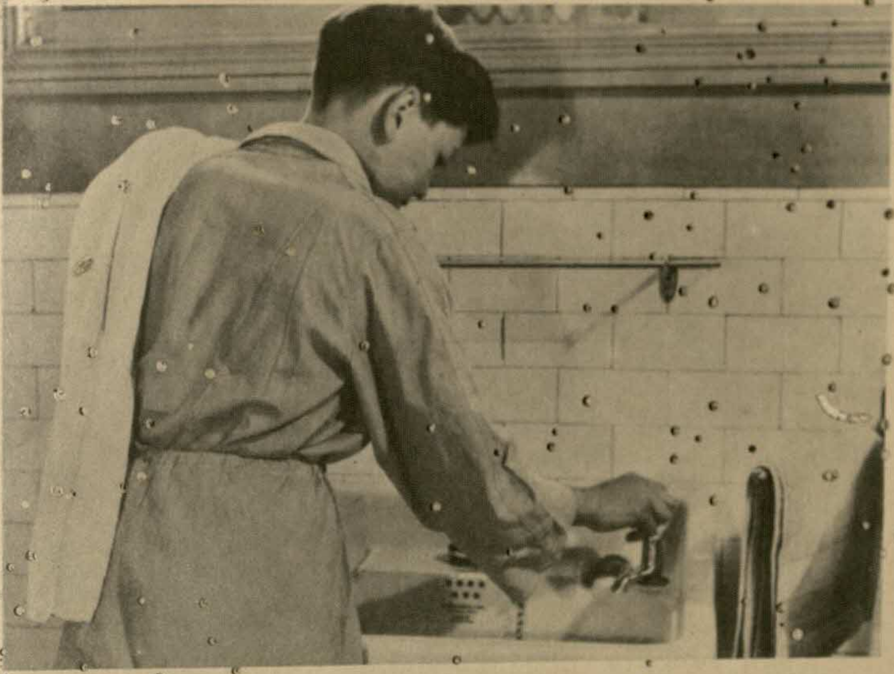

OXFORD STREET
SOHO SQUARE
REGENT STREET
WORK HOUSE
BROAD STREET
STREET
STREET
• Location of pumps
. Location of fatal cholera cases
-- Boundary of equal distances between Broad Street pump and other pumps

DOCTOR SNOW, DETECTIVE

LONDON did not have a system of sewers and main drainage until as late as 1865, and it was only fairly recently that water was piped to houses instead of being collected from pumps. Some of the water from these pumps drained from puddles in the streets, where all kinds of rubbish and refuse were tipped. In the overcrowded slums of the towns, conditions were very bad, and diseases spread quickly. Among the poorer people life was often extremely short.

You will have heard of the "Plague". Had London been as clean then as it is today this would never have happened. Smallpox, which left people pock-marked for life, typhoid and typhus were all common diseases in the dirty areas, some of the dirtiest being the prisons.

It was in the 19th century that improvements came both in the removal of waste, and in the supply of water. At this time too, more was discovered about the nature of disease and how it was transmitted. Cholera, another disease, provides an interesting example of this. A London doctor, named Snow, who lived at this time began to collect



THE BROAD STREET PUMP

all the evidence he could about the causes and spreading of cholera. He found that the disease was taken into the body through the mouth, and that it was excreted from the body and could be passed to others by water polluted by sewage. In 1854 an outbreak of cholera in Central London caused nearly 600 deaths in two weeks. Doctor Snow plotted these cases on a map, and found that they were all grouped round a particular pump. It was this that led him to the fact that the disease was water-borne. This is only one instance, but it is typical of the growing determination to conquer disease. Today a high standard of cleanliness, and the advancement of medical science, cause many diseases to be rarely heard of.

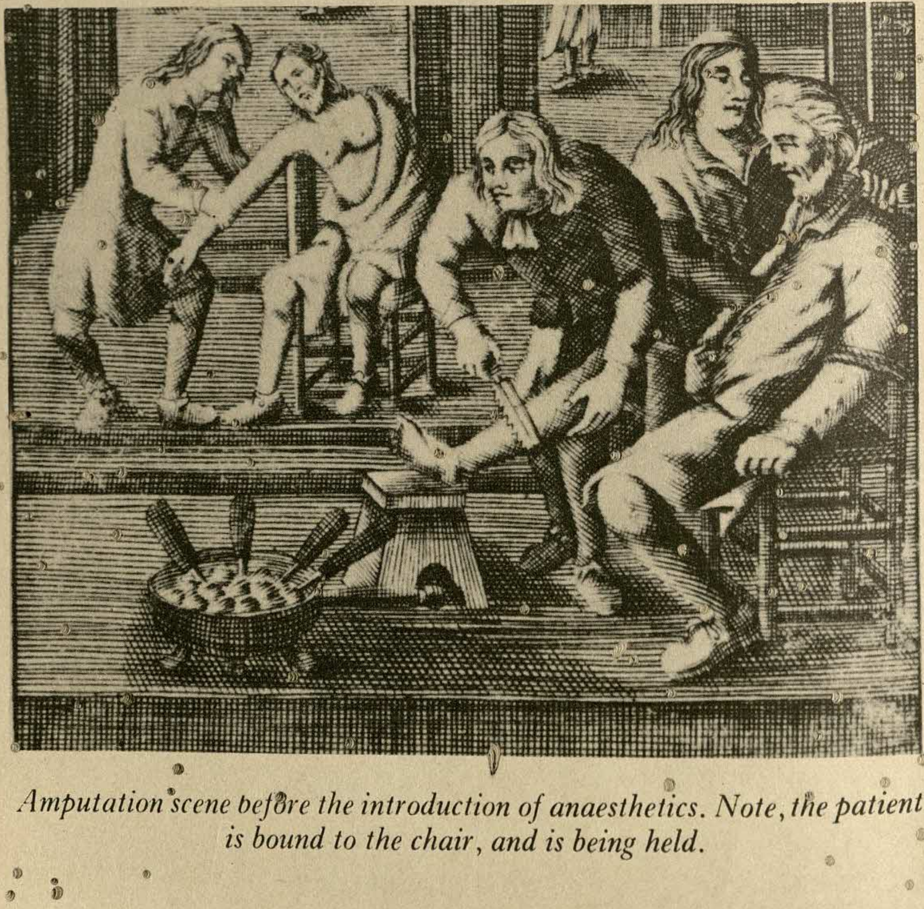
Look at the photograph above. Which water would you rather use, water from this tap or water from Dr. Snow's pump? Why? Does the picture suggest any other changes that have taken place in our daily way of life in the last hundred years or so?

Make a large drawing like the photograph showing the same things but as they would have been a hundred years ago. How would the boy have been dressed then? Would he have used a wash basin?

AN OPERATION, 1692

TODAY if we become ill, we may be sent to a hospital where we will receive the latest kind of treatment for our particular illness. Many forms of modern treatment have come about only in the last fifty years, and some of them are due to advances made by British doctors.

Compare the two pictures and the conditions shown in them. Look up the word "anaesthetic" in your dictionary. Years ago even large operations were done without an anaesthetic and the patient suffered great pain. Even if the operation was successful, the patient often died, not from the effects of the operation, but from infection by germs (bacteria) that entered the wound at or after the operation. As soon as it was realised that the infection was caused by bacteria, antiseptics were used in the operating theatre and elsewhere to kill the

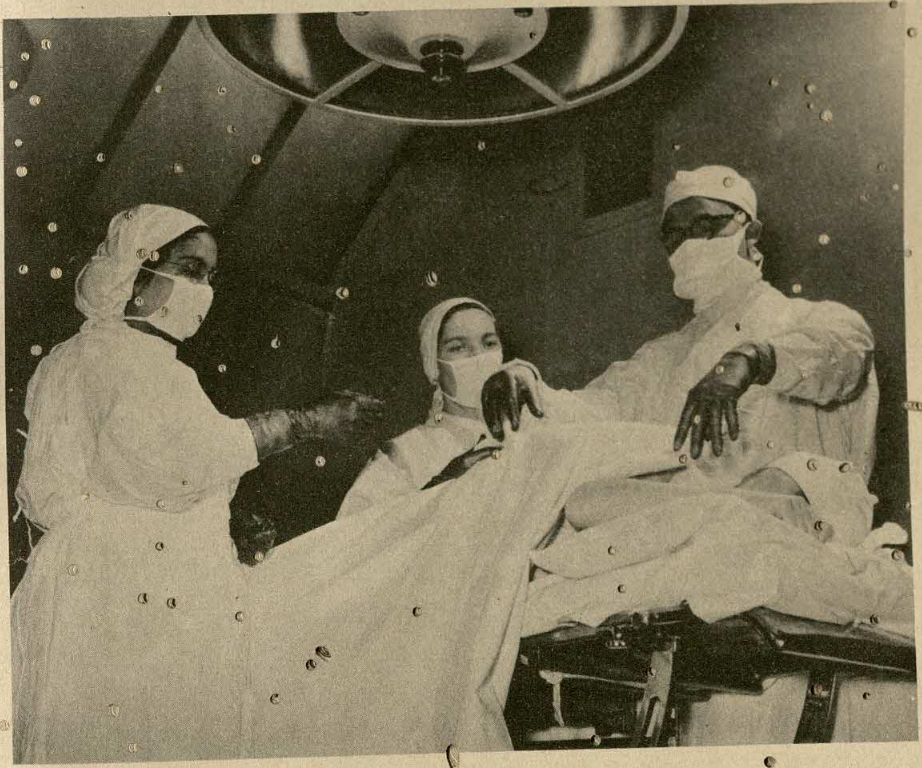


Amputation scene before the introduction of anaesthetics. Note, the patient is bound to the chair, and is being held.

germs. Antiseptics are still used for many purposes, but in the operating theatre today the surgeon relies on asepsis, that is, not allowing any bacteria to be present. When anything is completely free from bacteria, it is called sterile.

Even with the greatest care a few bacteria may invade the wound. These are dealt with by the new wonderful drugs called antibiotics. You have probably heard of the one called penicillin.

There are many names connected with the great advances in medicine, and here are a few of them. Florence Nightingale, Pasteur, Jenner, Lister, and Fleming. Find out what you can about them, and any others that you come across in your reading, and write their stories in your own words in your record books.



A modern operation in progress.

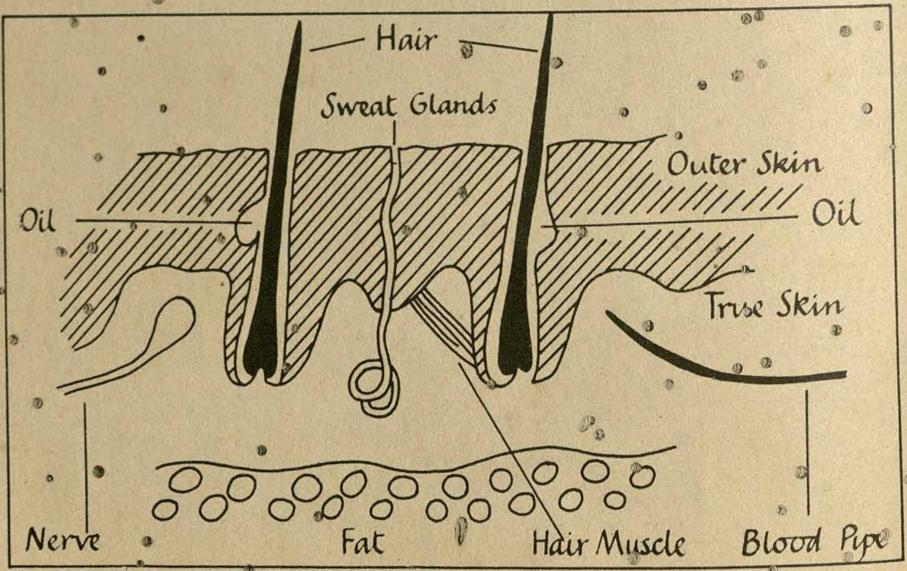
HEALTH DEPENDS—

ALTHOUGH our homes and towns are very much cleaner than they were and medical treatment is so much more effective, we must still be careful to be as healthy as possible. What do we mean by health? The dictionary says that health is the reaching and keeping of the highest mental and bodily vigour of which we are capable.

There are many things that go to make us healthy. Cleanliness, sufficient exercise, enough sleep, fresh air, sensible clothing and warmth. All of these are important and we will talk about each in turn. Apart from healthy bodies, healthy minds are just as important.

When we look at our skin we do not see very much, but if we examine it under a microscope it appears much more wonderful. Look at the drawing of a magnified section of it. The outer layer is really in two parts. The top layer is horny and hard, especially on the palms of our hands and on the soles of our feet. It is made up of cells. Softer cells from underneath are all the time growing out to the surface where they harden. These replace the outer layers that are being rubbed or scratched away all the time. The outer layer keeps out dust, germs and water.

Hundreds of tiny hairs grow from the skin, but they are so fine that they are useless for keeping us warm, in contrast with the hair of many



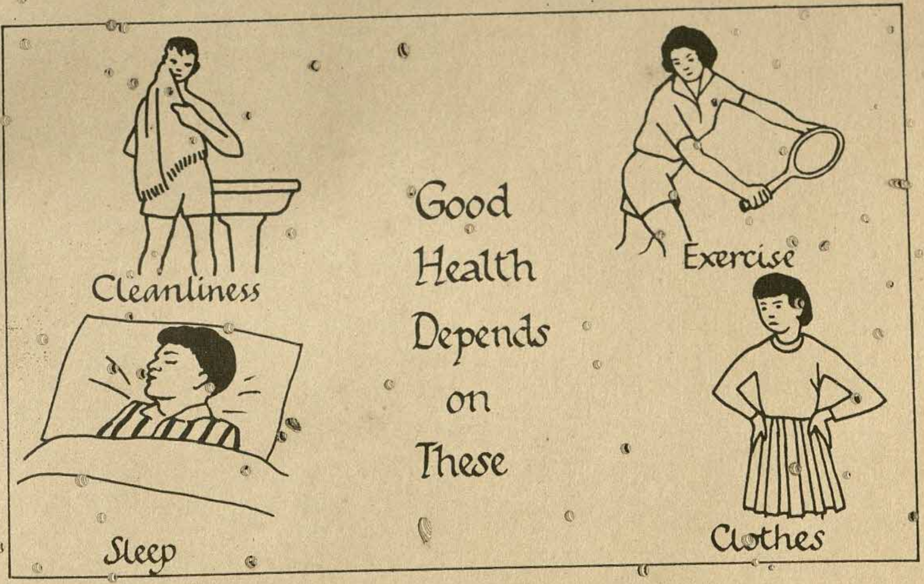
animals. There are muscles too under the skin which allow us to move certain parts, like the forehead, although many of these have fallen into disuse.

As well as hairs, there are oil glands in the skin; can you say what they are for? You can probably guess if you have ever had your hands in a solution of water and one of the modern washing products, and then tried to pick up some fine material.

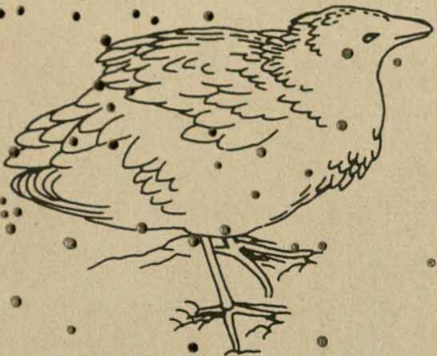
There are also hundreds of tiny sweat-glands which when we are warm or hot pour out water which contains salt. The water evaporates leaving behind the salt. This evaporation helps to keep us cool. Then there are the nerves that give us the feelings of pain, of hot and cold, and of touch as well as the tiny tubes that carry the blood supply.

Besides the dirt that gets on our skin from the outside there are all the waste products from the body, such as dead skin, oil and dried sweat that must be removed with soap and water. Cleansing the skin keeps it clean and a clean skin allows our bodies to work properly.

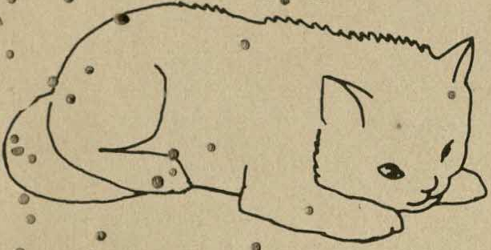
Make two drawings in your record books, one of a schoolboy or girl of the Victorian days, and a modern schoolboy or girl. Underneath list the advantages of our way of dress over that of the Victorian child in regard to health.



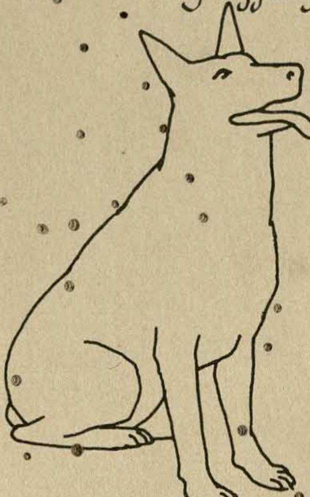
KEEPING COOL—



A bird with fluffed feathers



Cat with fluffed fur



A dog on a hot day

WHEN we are hot we do not feel like eating large meals, nor do we feel like taking violent exercise. But when we are cold we feel much more like exercise and big meals. Why is this? Both eating more food and taking more exercise have the effect of warming us. Food that we eat is turned into a form of heat or energy inside us and this warms us. When we take exercise the movement makes us warm. If we are very cold we shiver. This is a form of exercise, and although we are not warmed-up by it, at least we are prevented from getting colder. These are some ways of avoiding getting too cold, by generating heat.

Another way is to cut down the heat that is lost from the body. On a cold day the skin is cold so blood that flows near the skin will be cooled down quickly. If the amount of blood that flows near the skin can be made less in cold weather then less heat will be lost. How much blood flows through the blood-vessels can be controlled by the nervous system through the muscles. When it is cold, the muscles allow less blood to flow through these tubes near the skin, and less heat is lost.

Have you ever noticed that on cold days birds fluff out their feathers? Why do they do this?

—AND KEEPING WARM

Can animals do the same sort of thing with their fur or hair? Remember air is a bad conductor of heat. We cannot do this sort of thing, but we can wear suitable clothing.

Just as there are ways of keeping warm, so there are ways of keeping cool in hot weather. How does a dog keep cool? We could stand in a breeze on a hot day, but there are ways of keeping cool controlled by our bodies.

When liquids evaporate heat is needed to turn the liquid into vapour. In our skin there are hundreds of tiny sweat glands which pour out water with a little salt in it when we are hot. The water evaporates taking heat from the skin. Then on a hot day the muscles allow more blood to flow near the skin and more heat is lost in this way. The face becomes flushed with blood near the skin.

Can you answer these questions?

1. Why is it a good thing to put on a sweater or coat after violent exercise?
2. Does it matter if we sit in wet clothes in a breeze?
3. Why do we feel uncomfortable on warm wet days?
4. Should we dress according to the time of the year or according to the weather?

Cool summer clothes

Warm winter clothes

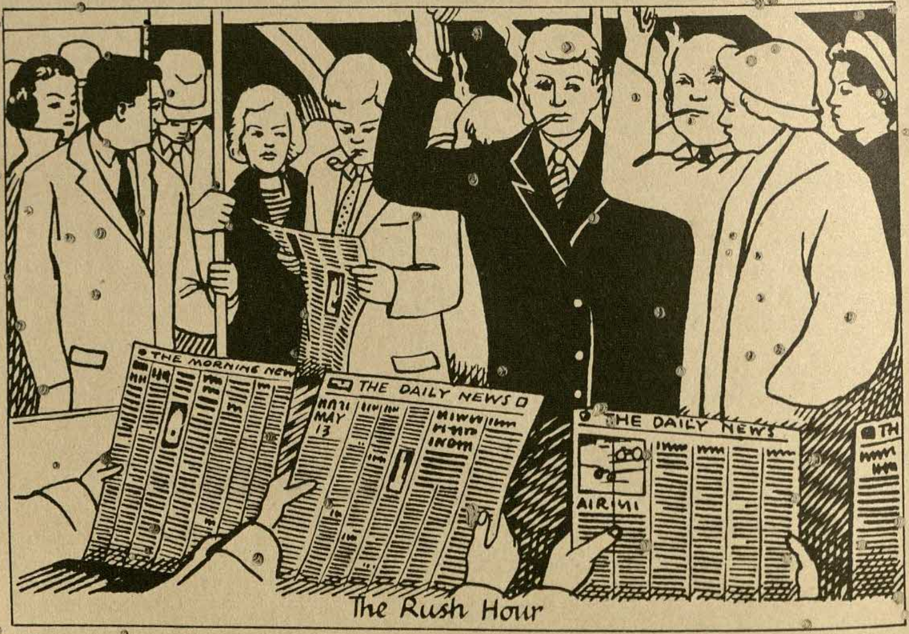
CROWDED ROOMS ARE—

MOST of the arrangements for keeping our bodies at the right temperature work without any control by us, but we can control the temperature of our surroundings. In our houses and schools we control the temperature and this puts less strain on our bodies.

In a crowded room, where the ventilation is bad, people soon begin to feel uncomfortable. Conditions like this are not only found in rooms, but are met in other places such as underground trains in the rush hours.

At one time it was thought that this feeling of discomfort was caused by all the carbon dioxide that people breathe out. This has been shown to be wrong, for even under conditions of great crowding the amount of carbon dioxide gets nowhere near the danger level. There is always enough air, and therefore oxygen, leaking in through the cracks to prevent this danger level being reached.

The discomfort is due to the fact that we breathe out water vapour as well as carbon dioxide. When we are in a crowded room with all the windows and doors closed, the heat will be lost only slowly and the temperature of the room will rise. Our sweat glands will therefore pour out water which normally would cool us. But not here, because the damp air, laden with water vapour from the breath, makes it difficult



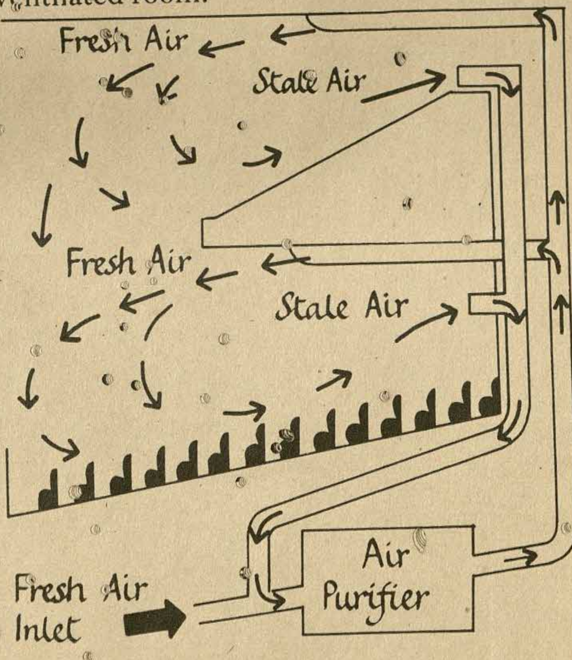
The Rush Hour

for the sweat to evaporate. So there is little or no cooling effect, and we suffer discomfort.

What can be done to improve conditions of this sort? It is no good just moving the air about in the room by a fan, for this will neither cool it nor will it take away any of the moisture. The supply of air must be replaced by cooler and drier air. In other words the room must be ventilated. When large rooms and buildings are artificially ventilated, the incoming air is often filtered to take away the dust, as well as being adjusted to the right temperature first. Of course ventilation, carrying away the impure air, lessens the risk of infectious germs being passed from one person to another.

Large buildings, such as factories and cinemas where there are often large numbers of people, must have good ventilation. The diagram shows you one way in which the atmosphere is kept fresh in a cinema or theatre.

Where else can you have a stuffy atmosphere? How about in your bedroom? Is there always a supply of fresh air there? A room can always be well ventilated without there being a draught. Provided that you keep warm it is better to sleep in a field rather than in a badly ventilated room.



This shows one way of keeping the air fresh in a cinema

The stale air is taken out through extractors at the back.

Fresh air enters through false beams.

The sweep of air is above the heads of the people.

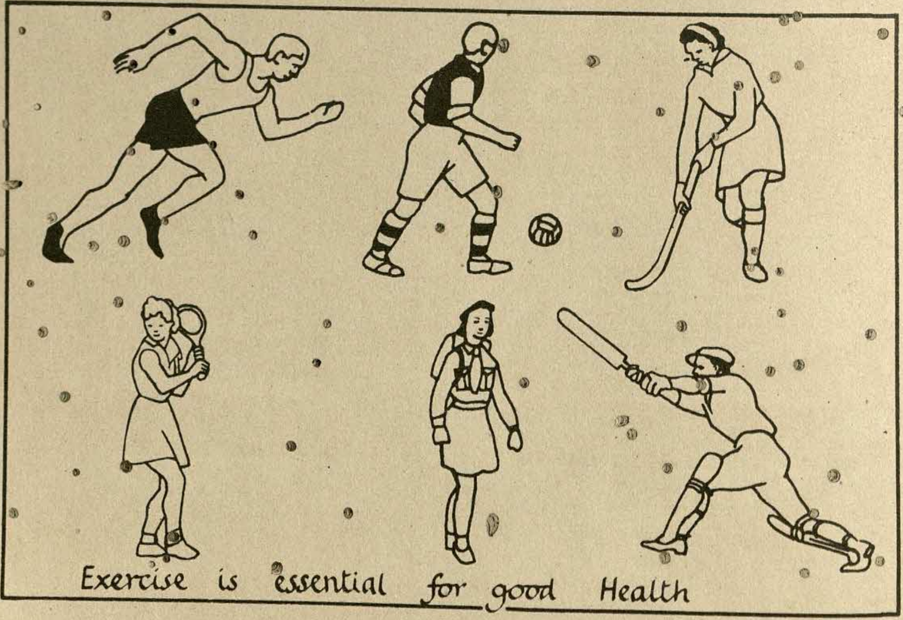
IN ORDER TO KEEP HEALTHY—

BOTH exercise and sleep are essential for good health. Exercise does many things for us. Here are some of them. You will notice that in the next paragraph two words are given in brackets where only one can be used correctly. Copy the sentences into your record book using the correct word in each case.

Exercise gives us a (good, bad) appetite, because food material is used up (slowly, quickly). Muscles and bones develop (slower, faster) when we exercise regularly. It also makes the blood flow more (quickly, slowly) through our veins. Games are a form of exercise and teach us to control our muscles as well as our (hands, ears) and our legs and eyes, and our (mouth, arms).

How many games can you think of where you:

(*a*) use a ball;
(*b*) do not use a ball;
(*c*) do not need your hands;
(*d*) only use your hands to touch the ball;
(*e*) need many different coloured balls;
(*f*) need both a bat and ball;
(*g*) need a stick but *not* a ball?

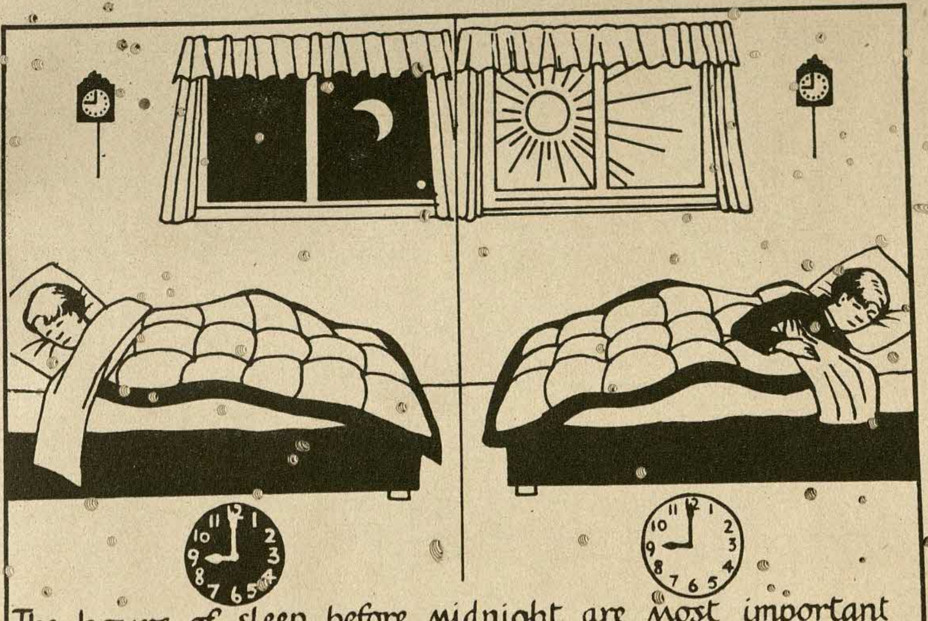


Exercise is essential for good Health

When you are growing and learning you need sleep, and lots of it. It is most important to get enough sleep. No amount of food or fresh air will make up for the lack of it. You have probably noticed that young children need much more sleep than grown-ups. How often do you complain when you are sent off to bed before your older brothers and sisters? The very young need very much more sleep, and it is just the same with young animals. Often a young kitten or puppy, playing quite happily, will suddenly go off to sleep just where it is playing. Newly-born babies spend most of their early days sleeping. But as they grow older less and less is required. There is no fixed amount of sleep for adults, the amount varies from person to person. Possibly the average for most adults is about eight hours a night. To lie in bed late in the mornings may be your idea of pleasure, but in fact it is the sleep that you get soon after going to bed that does you most good.

Can you answer the following questions?

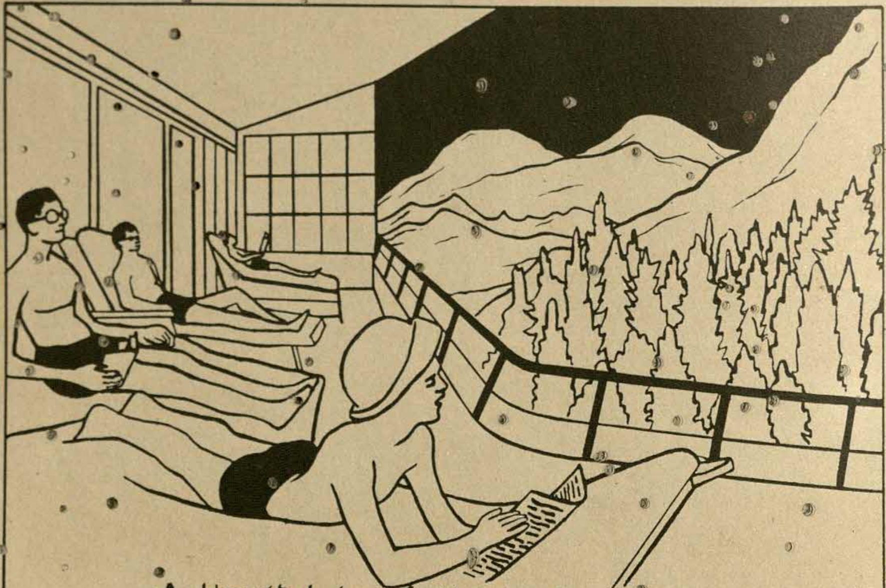
(*a*) Do all plants and animals sleep?
(*b*) What types of animals hibernate?
(*c*) How is your body temperature maintained while asleep?
(*d*) Why is it bad to have a big meal before going to bed?


The hours of sleep before midnight are most important

MORE ESSENTIALS

AS well as fresh air, which is most necessary for our general health, there is something else that is very closely connected with it. You have probably seen pictures of sick people who have been sent to Switzerland for their health, and you may have noticed how they dress while staying there. People who go there for health reasons, usually wear as little clothing as possible and they rest in the open air. In Switzerland the mountain air is free from dust, and usually there is plenty of sunshine. It has been found that exposing the body to the sun is very good for health. But too much sun can be dangerous. Regulated amounts of sunshine have been found very good for the skin and for general health, and many disease germs cannot live in bright sunshine.

We have talked about the importance of keeping the skin clean, but this is not all. The cleanliness of our mouths is of the utmost importance too. All too often we forget that any poisons that are made in the mouth by bad teeth pass from them into our bodies, and cause many upsets. Regular cleaning of teeth, night and morning, especially at night, will remove any food particles that lodge in our teeth and



A Hospital in Switzerland

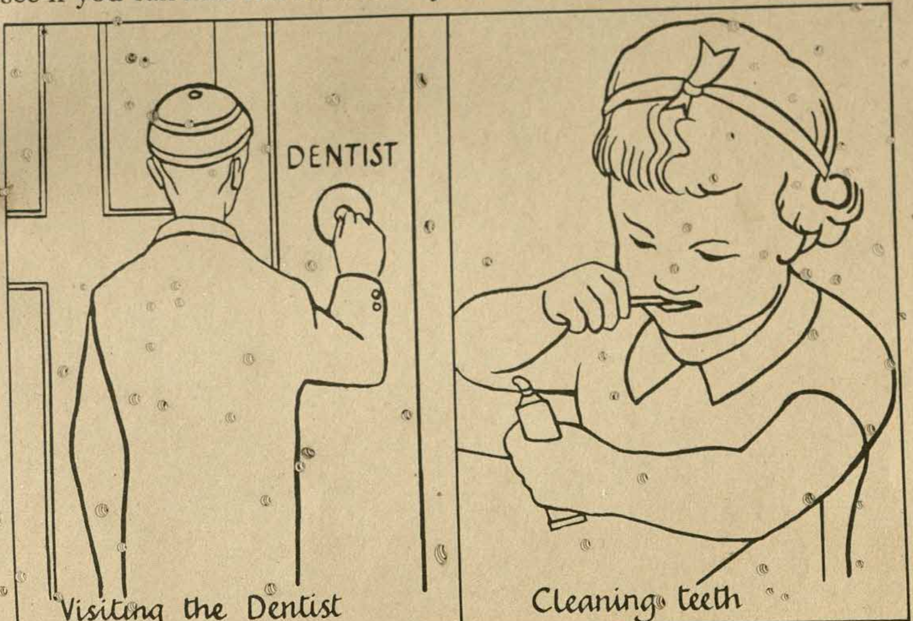
around our gums, and this helps to prevent decay. We should visit the dentist regularly too, for then any slight troubles can be put right in the early stages. Bad teeth prevent us chewing our food properly, and when they are replaced with artificial ones they are not as efficient as our own teeth. We shall see later on how certain food materials help us to have good teeth.

Just as it is necessary to keep the outside of our bodies clean so it is necessary that the inside should be clean too. Regular habits in the working of the bowels prevent waste food collecting inside and are extremely important.

The final essential to good health is good food, and the right sort of food. This we shall be dealing with next time.

1. It is said that "Eskimos never have toothache". Do you think this is true, and if so, why?
2. Why do we become sunburnt in the summer?
3. Which is the correct method of brushing your teeth?

Can you answer these questions? When next you visit the library see if you can find the answers if you do not already know them.



Visiting the Dentist

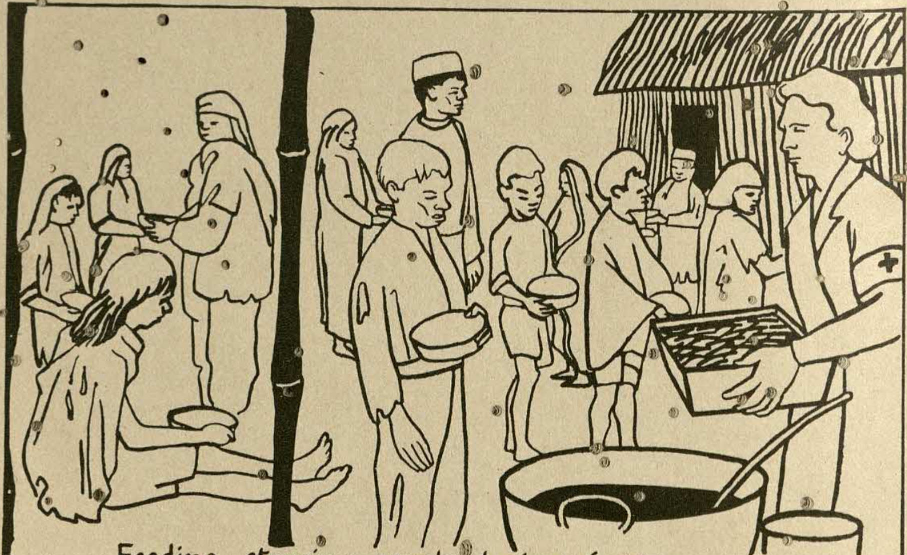
Cleaning teeth

GOOD FOOD IS NOT—

DO you remember that we talked about several topics connected with food in our first book? We said, for example, that food is cooked for several reasons. What are they? We eat and enjoy our food, but probably never stop to think what it is like to be without it. As we do for so many things, we accept the fact that it is there when we want it. It is generally true to say that most people in Britain get enough to eat. But today there are parts of the world where the people do not get enough good food. War, too, brings food problems. For health to be kept up everyone must have enough of the right kinds of food.

On the other hand we must not overeat. It probably does us no harm to eat too much on some occasions, and we probably enjoy doing it, but as a regular thing it is far from good, and can lead to illness.

When we talked about this before we said that although we have such a variety of foods they are all made up of a few basic materials. Water is of course an essential, for although man can exist without food for several weeks, he could only live a few days without water.



Feeding starving people during famine

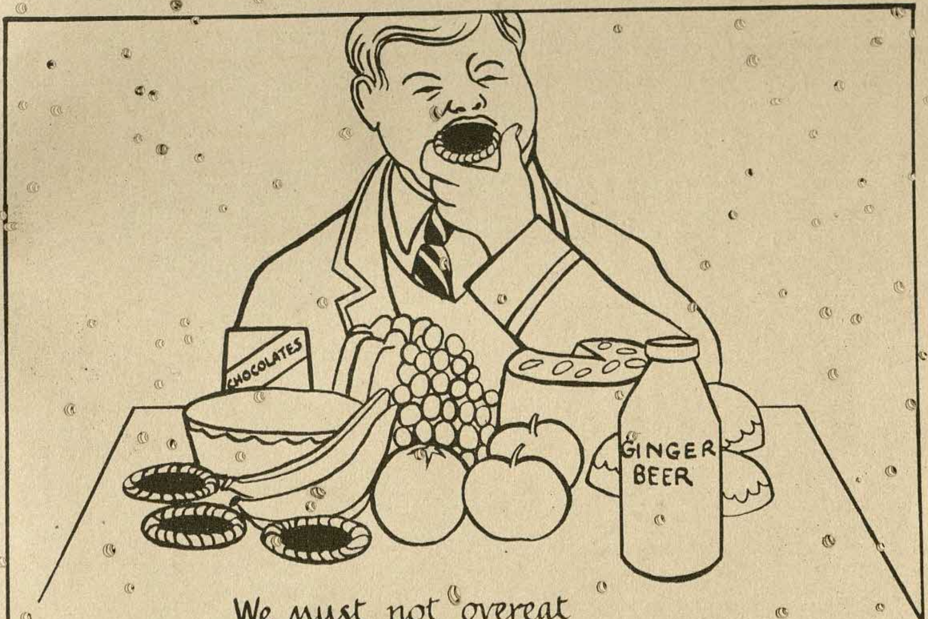
—NECESSARILY RICH FOOD

Can you remember the basic materials of all food? Here is a table:

Proteins	Body building and growth	....
Carbohydrates	Energy	....
Fats	Energy	....
Minerals	Body building and growth	....
Vitamins	Control the use our bodies make of food	....

These materials, that is, proteins, carbohydrates, fats, minerals and vitamins are called the "Famous Five". In the table above the last column has been left blank. Copy the table into your record books and fill in the blanks giving examples of the food that contain the various materials.

When we consider all the different types of food that we eat as a whole we call it a diet. When we have enough of each type of material for our needs we say that our diet is balanced.



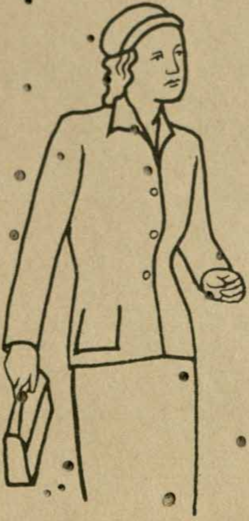
We must not overeat

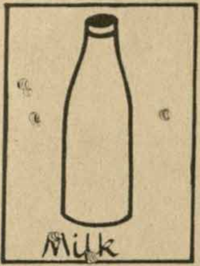
PROTEINS

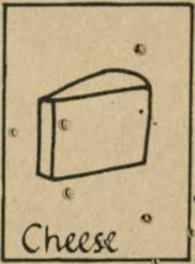
WE must have enough proteins in our diet. They are needed for:

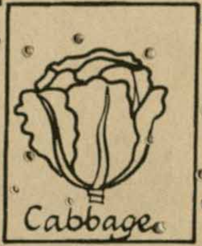
1. Body building
2. Growth
3. Replacement of wear and tear.
4. To help us to resist disease.

Excess protein foods are turned into fat, heat and energy. This is wasteful and expensive, because heat and energy can be supplied by carbohydrates which are much cheaper to buy.







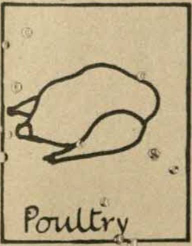


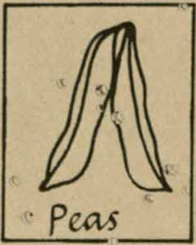
PROTEINS

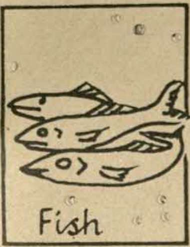
They contain carbon, hydrogen, oxygen, nitrogen and sometimes sulphur and phosphorus joined together. They come from two sources:

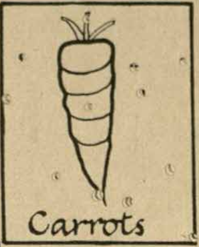
1. *Animal*	and	2. *Vegetables*
Meat	Game	Green vegetables
Fish	Milk	Root vegetables
Cheese	Eggs	Peas and Beans
		Seeds and Nuts

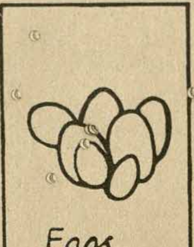
The animal sources of protein contain a higher proportion of proteins than the vegetable proteins. Plants make their own proteins, but they lack something that animal proteins have. Animals start with plant proteins and then make their own. Animal proteins are more complete than vegetable proteins.

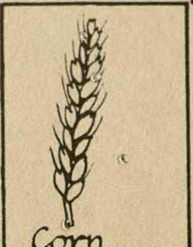


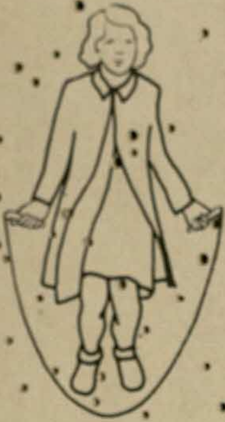








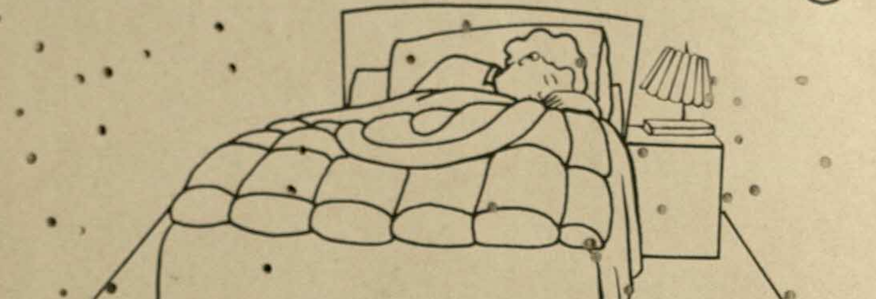


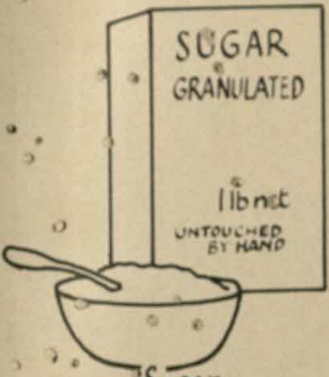


CARBOHYDRATES

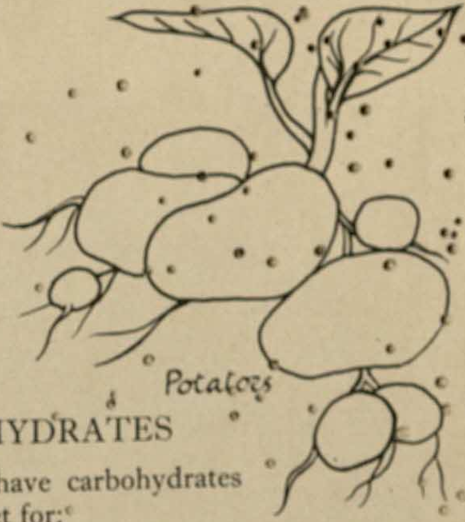
These contain carbon, hydrogen and oxygen joined together. They come from two main sources.

1. *Sugars* and	2. *Starches*
They are sweet and dissolve in water.	Plants store their food in this way.
Sugar	Potatoes
Honey	Cereals
Fruit juices	Bread





Sugar



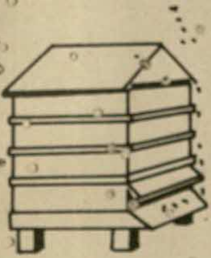
Potatoes

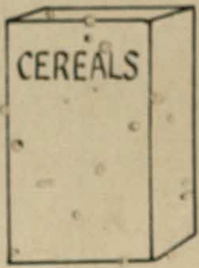
CARBOHYDRATES

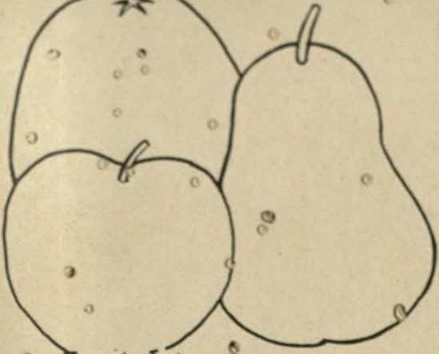
WE must have carbohydrates in our diet for:

1. Energy to maintain our body temperature.
2. Energy for any kind of body movement.

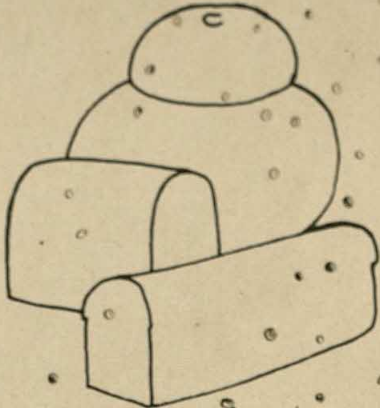
With the air that we breathe, the carbohydrates act as "fuels" to give energy. Excess carbohydrates can be converted inside us to fats and stored away for future use.



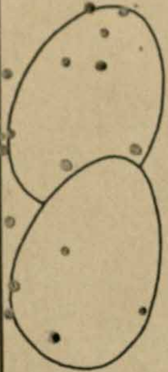


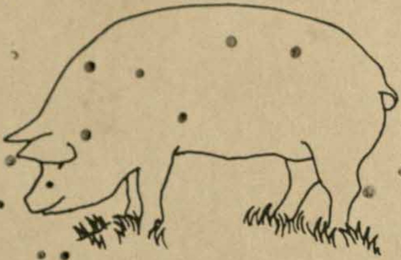


Fruit Juices



Bread



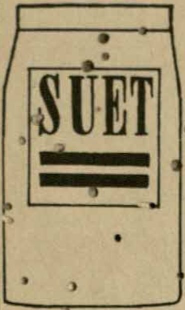


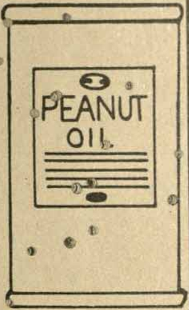
FATS

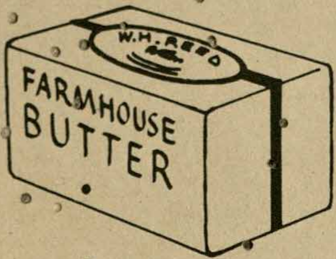
WE must have fats in our diet for:

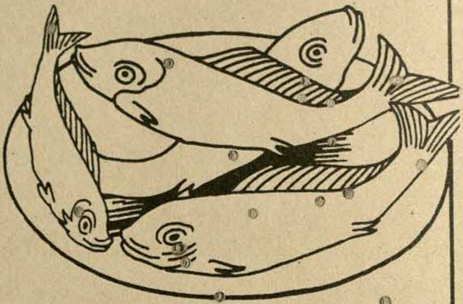
1. Heat and energy.
2. To form body fat.
3. For the vitamins some of them contain.

Fats give us twice as much heat and energy as an equal amount of protein or carbohydrates.

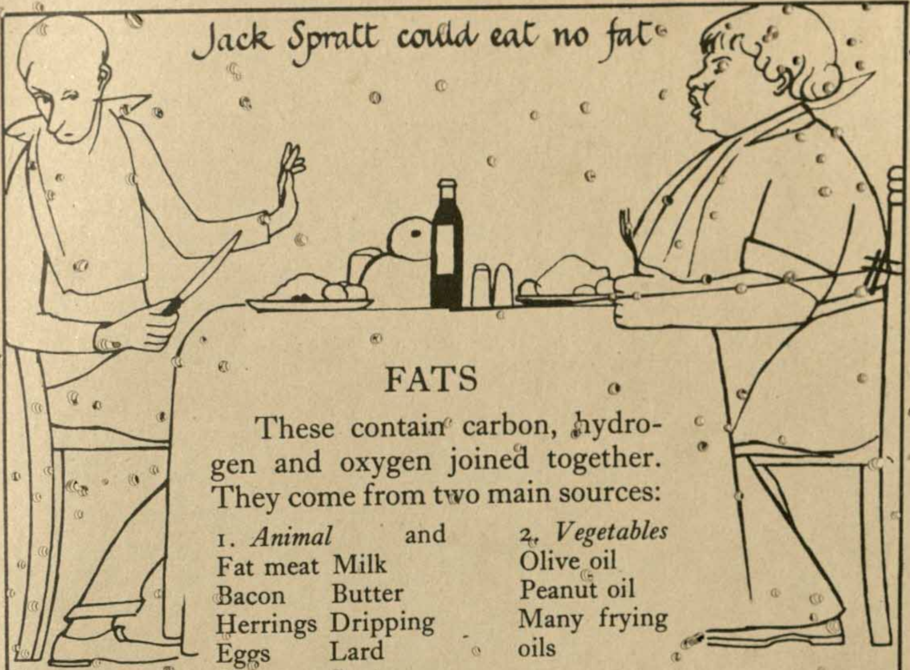








Jack Spratt could eat no fat



FATS

These contain carbon, hydrogen and oxygen joined together. They come from two main sources:

1. *Animal* and

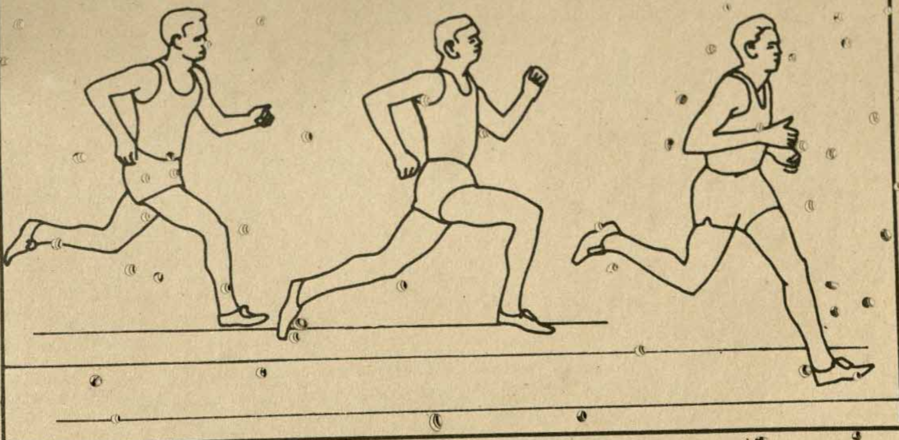
Fat meat
Bacon
Herrings
Eggs
Cheese
Fish oils

Milk
Butter
Dripping
Lard
Suet

2. *Vegetables*

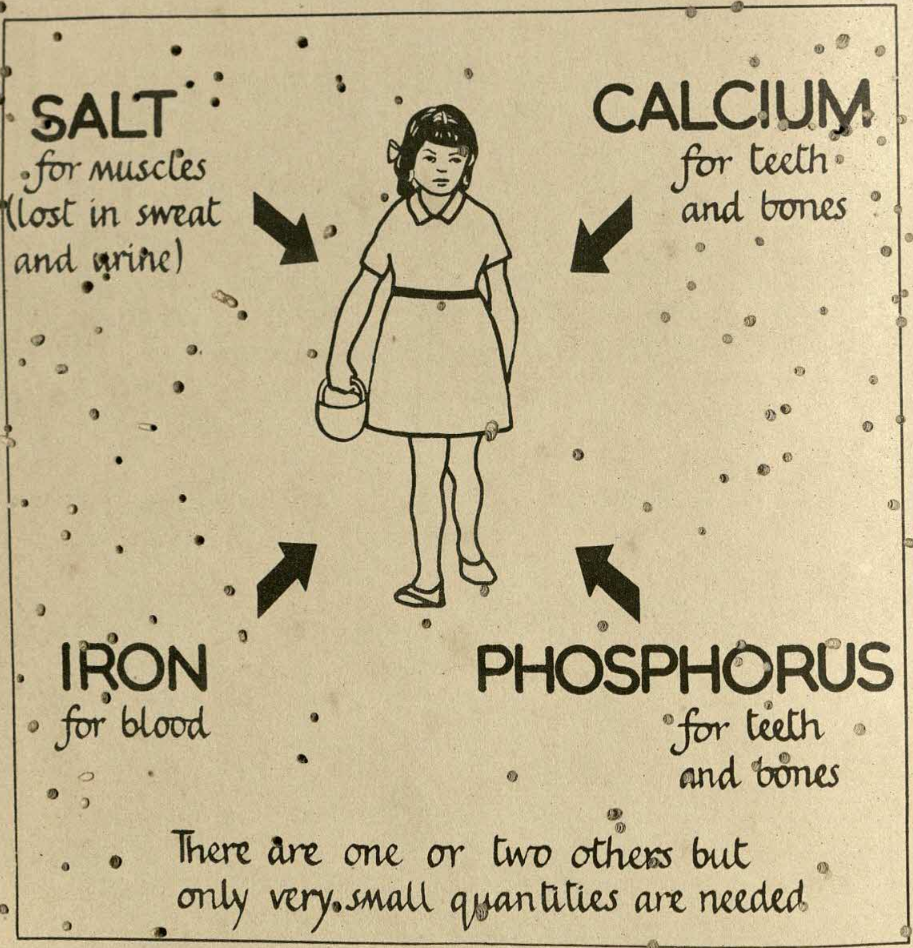
Olive oil
Peanut oil
Many frying oils

His wife could eat no lean



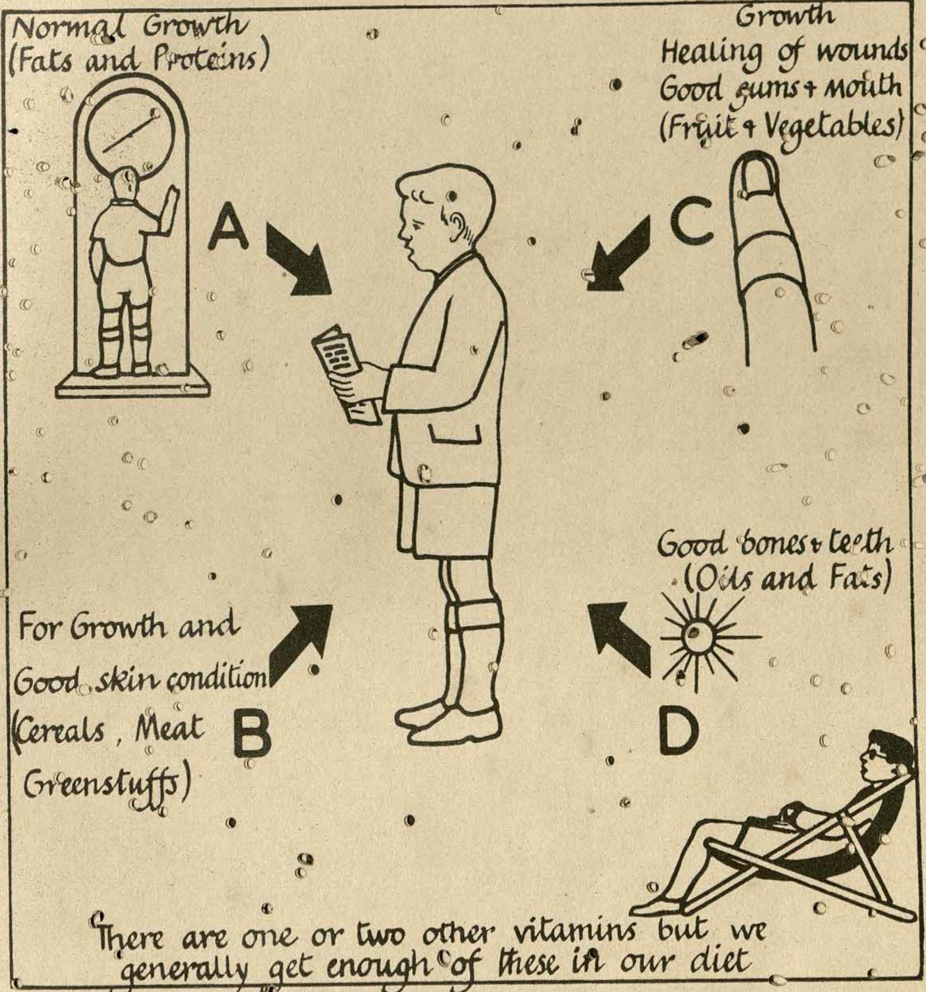
MINERALS IN ANIMALS AND VEGETABLES

ALTHOUGH our bodies need relatively small amounts of the common materials, they are just as essential to our well-being as proteins, carbohydrates and fats. Do you know what is meant by the word "mineral"? If you do not, look it up or ask your teacher. The complete story of the value of these substances to our health is rather complicated, and it has been simplified here for you, but do not think that this lessens the importance of them. Again a good, varied and balanced diet will provide you with all that you need, except perhaps in one or two cases.


SALT
for muscles (lost in sweat and urine)
CALCIUM
for teeth and bones
IRON
for blood
PHOSPHORUS
for teeth and bones
There are one or two others but only very small quantities are needed

THERE IS NO MAGIC ABOUT VITAMINS

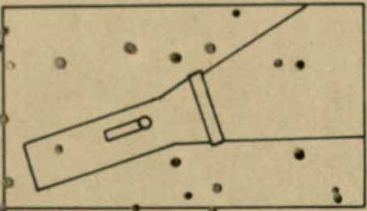
THERE is no magic about vitamins. We all need them in very small quantities, and only rarely do they have to be taken by themselves, such as in the treatment of some illnesses and perhaps during growth. A good, varied and balanced diet provides us with all that we need. You can see from the pictures below that foods which provide us with protein, fats and carbohydrates are the ones that also supply us with nearly all the vitamins that we need.



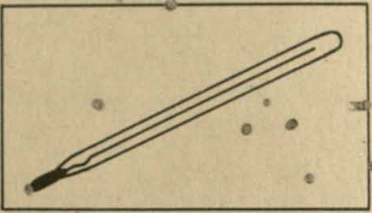
There are one or two other vitamins but we generally get enough of these in our diet

HERE ARE SOME SIMPLE EXERCISES

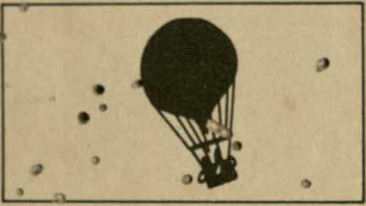
HERE are sixteen different pictures. Each of them shows a scientific fact. Underneath the pictures are statements for you to complete. Do *not* write in this book but copy the statements into your record books and complete them. Copy the pictures as well.



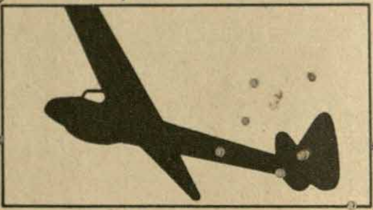
Light travels -------



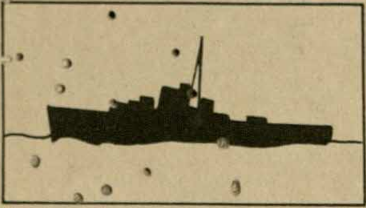
The clinical thermometer is marked from 95°F/110°F because ----



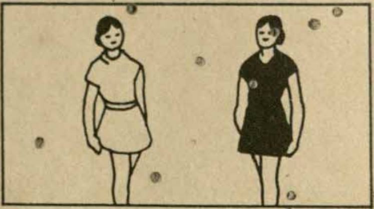
A Balloon rises because ----



A glider makes use of ---- to fly



Steel is denser than water. A steel ship floats because ----



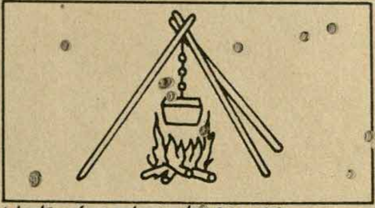
White clothes are ---- to wear than black clothes in summer

Heat travels in three ways

1 ______________

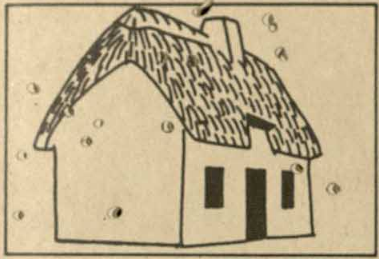
2 ______________

3 ______________

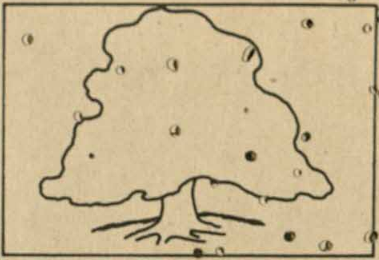


Hot air rises because ----

HERE ARE SOME SIMPLE EXERCISES



A thatched roof keeps a house ___ in winter and ___ in summer



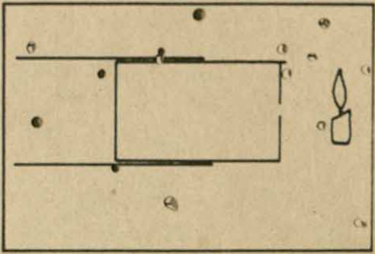
Water enters through the ___ passes up the ___, and is lost through the _____

The effects of an electrical current

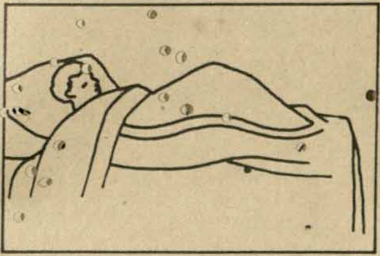
1 __________

2 __________

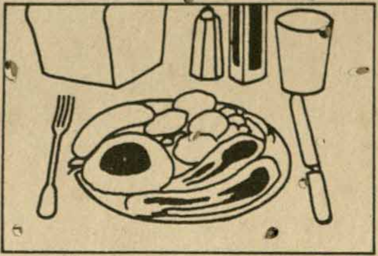
3 __________



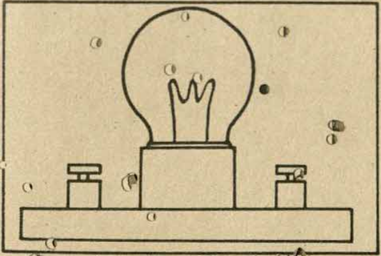
The image in the pinhole camera is _________



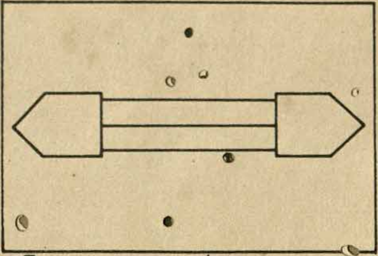
Sleep is necessary for _____



Food is necessary for _____



There are two terminals because ___



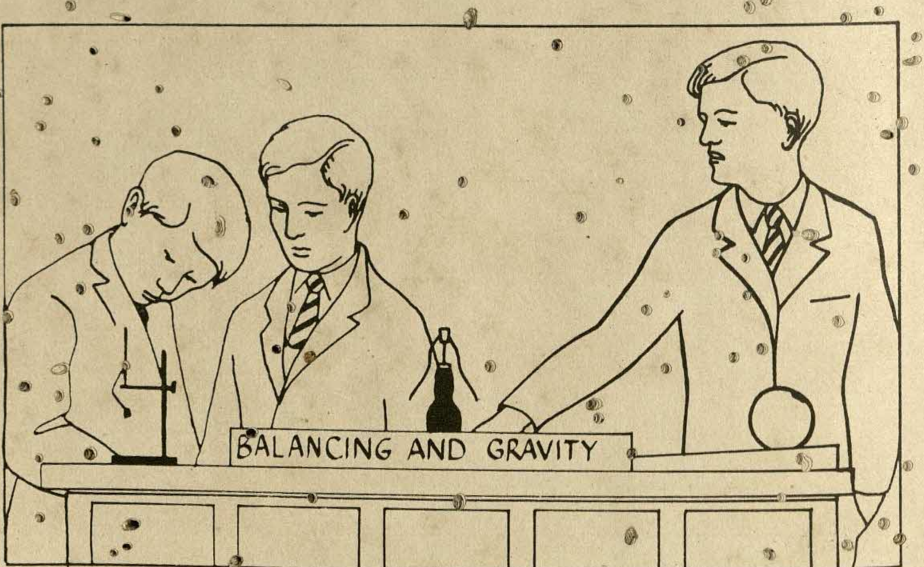
Fuses are used to _____

HOLDING AN EXHIBITION

At the end of our science course last year it was suggested that you should hold an exhibition on your school "Open Day" or "Parents' Day". Did you do this? I hope if you did that it was a great success. You may remember that we said the type of exhibition you held depended upon the size of the room you used for it. This still holds good of course, for this year. But even so you should try to include as many examples as you can of the different ways in which "Man uses his Discoveries".

This year you have your record books to work on, and they can be exhibited. They will also help you to set up some of the simple experiments, and to do some more posters to decorate the walls. Then there are the examples of balancing and gravity. Have you still got the simple toys you made? All of these are good material for you to use. But remember that you must be able to answer questions about them should you be asked.

You can, of course, include some of the material you used in last year's exhibition, or some of the things that you did last year but did not show. The scientific picture will then be more complete. It is a good plan to work in groups or teams of three or four, with a leader in each group.



DID YOU GET YOUR CROSSWORD RIGHT?

Solution of crossword on page 63.

1 A	R	2 O	O	3 N	■	4 M	5 A	G	6 N	E	7 T	■
I	■	N	■	8 E	V	E	R	■	E	■	9 H	E
10 R	O	O	11 T	S	■	12 A	M	■	O	■	E	■
■	■	13 M	E	T	■	S	■	■	14 N	15 O	O	16 N
17 S	18 T	E	N	■	19 R	U	20 N	S	■	X	■	O
21 T	O	N	■	22 F	I	R	E	■	23 D	Y	24 E	■
E	■	■	■	■	25 S	E	T	26 S	■	27 G	A	28 S
29 A	V	E	R	30 S	E	■	■	31 A	32 L	E	R	T
M	■	■	■	E	■	■	■	33 D	E	N	S	E
■	34 R	A	R	E	F	Y	■	■	E	■	■	M

Solution of crossword on page 97.

1 T	■	2 E	■	3 G	■	4 N	■	■	■	5 S	W
6 H	E	L	I	U	M	■	7 D	A	8 T	E	■
E	■	E	■	N	■	■	U	■	A	■	■
R	■	9 C	10 O	N	11 D	U	C	T	I	O	12 N
13 M	O	T	H	E	R	■	T	■	L	■	I
O	■	R	■	14 R	A	Y	■	■	■	■	T
M	■	I	■	■	I	■	15 W	16 A	T	E	R
17 E	T	C	H	I	N	G	■	I	■	■	O
T	■	■	■	■	■	■	18 W	R	19 O	N	G
20 E	21 E	L	■	22 S	23 A	24 T	■	■	A	■	E
25 R	A	D	26 I	A	T	E	■	■	R	■	N
■	R	■	S	C	E	N	T	■	S	■	■

ARE YOU A DETECTIVE?

A SCIENTIST is always looking, asking and watching. In fact he is a kind of detective, a scientific one if you like. During our science course you too ought to have been looking, asking and watching.

In our first book and in this one it has been suggested that you should use your local library as much as possible to find out all the kinds of books that had topics of special interest for you. If you have been doing this you should have read quite a lot of books in the last two years. In many of them you may have found difficult diagrams and pictures. But you must remember that most of them are simple in themselves, and in most cases the details that make them appear so complicated are the extra things that make the whole work so much better.

In "Man uses his Discoveries" you have been asked two questions over and over again. They were "have you noticed?" and "can you explain why?" By thinking hard and using your eyes, and in some cases asking questions, both of other people, and of yourselves, you are becoming the scientific detective. By doing this you are doing what all scientists do, but on a much smaller scale, and you are going a long way to understanding many of the wonderful things about us today.

In this book we have tried to see how man has used his simple discoveries to travel further in the field of science. In our next book, which is called *The Growth of Science*, we shall see how man has extended his experiments and enquiries still further.